Nature

A WEEKLY

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A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

"*To the solid ground*
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THURSDAY, MAY 2, 1889.

THE NEW CODE AND SCIENCE TEACHING.

THE new Code of the Education Department[1] is now lying on the table of the House of Commons, and never, since the famous proposals of Mr. Mundella, has there been so much stir among those interested in primary instruction as at the present moment. The reason is not far to seek. For some years a Royal Commission has been sitting and taking evidence, and it has produced several bulky Blue-books during the course of the past year. It was known that the Commission was divided into a majority and minority who were strongly opposed to one another on certain questions of policy. This has found expression in lengthy reports and contradictory recommendations; but, to the satisfaction, if not to the surprise, of educationists it is found that on purely educational matters there is an almost perfect unanimity between the two sections. It was therefore a matter of deep interest to see how, and to what extent, these recommendations, signed by every member of the Commission, would be embodied in the proposed Code of 1889.

At the outset it may be well to remark that there are several alterations in this Code which are almost universally allowed to be improvements. But it is conceived in a spirit of compromise, and perhaps no party is entirely satisfied with it. The only point we have to consider is the aspect of the Code towards the teaching of natural science.

It may be convenient to group our observations under different headings.

I. The direct changes proposed in the teaching of science. These are almost confined to one or two modifications in the geographical schedule, and to a provision that "Scholars of any public elementary school may attend science classes held at any place approved by the inspectors." This may be very useful in towns, especially as it will admit of the formation of central laboratories or work-rooms similar to the present cookery centres.

II. The proposed changes which will tend to facilitate the teaching of science. There are four subjects of instruction which are termed "class-subjects": English (including grammar, composition, and repetition of poetry), Geography, Elementary Science (a progressive course of object-lessons), and History; together with Needle-work for girls. Only two of these class-subjects can be taken for examination, and, under the old Code, "English" must necessarily be one of those chosen. The consequence of this is, that "Elementary Science" has never got a footing in our schools, for even where two class-subjects are taken, they are nearly always English and Geography, or English and Needle-work. The supremacy of English is now to be put an end to, so that any teacher may now take Elementary Science, if he or she should prefer it, and earn a grant.

The enormous waste of time and patience in making little children, even in our infant-schools, learn the spelling of common words, is to be reduced. The inspector is to give no dictation exercises to boys and girls under the second standard. This will give more time for object-lessons and other valuable modes of instruction.

Some relaxation of the literary requirements are also made in the case of evening schools.

The present system of payment by results is to be so modified that the cramming in the three R.'s will not be so profitable, and there will be more chance for intelligent teaching. One of the matters also to be taken into account by the inspector in assessing a school, is the provision of "apparatus," though this need not necessarily have anything to do with what scientific men would call by that name.

These proposed changes are in the right direction, but the value of many of them will largely depend upon how they are understood. There is a singular want of clearness in some of the clauses. The annual "Instructions to inspectors" have not been yet drawn up, and indeed it is very improbable that they will make their appearance until after the Code has become law. It is quite possible to take away with one hand what is given with the other. The present agitation is therefore of great importance

[1] "Code of Regulations, with Schedules, by the Right Honourable the Lords of the Committee of the Privy Council on Education." (Eyre and Spottiswoode.)

not merely in getting modifications of the Code when discussed in Parliament, but in inducing the Education Department to give their inspectors such instructions as shall secure that the greater liberty of teaching should be a reality; that the ominous word "repetition," introduced into one or two paragraphs may not become "English" in disguise; and that the spelling of the second standard should not involve a laborious preparation of the younger children.

III. These alterations bearing on the teaching of science fall far short of what the Royal Commissioners unanimously recommend. The report of the majority states that "some elementary instruction in science is only second in importance to the three elementary subjects:"—namely, reading, writing, and arithmetic, and it places among subjects regarded as essential, "geography (especially of the British Empire); lessons on common objects in the lower standards leading up to a knowledge of elementary science in the higher standards." It adds, "That geography, if properly taught, is a branch of elementary science, which should not be separated from the other branches, and might well be taught along with object lessons, in accordance with the recommendations of the Royal Commission on Technical Instruction"; "that the curriculum in the ordinary elementary schools might often include not only instruction in the elementary principles of science, but also, in certain standards, elementary manual instruction in the use of tools, and in higher schools and evening schools this work might be carried still further"; "that, in making future appointments to the office of inspector, it would be desirable, in regard to a larger proportion of them than at present, to give special weight to the possession of an adequate knowledge of natural science." The members of the minority express themselves, if possible, more strongly; and make such additional remarks as, "We are of opinion that, after the children have left the infant school, transitional methods should be adopted, which will develop their activity and train their powers by drawing in all cases, and by such other means as, for instance, modelling, or the collection and mounting of botanical specimens."... "If science is to be well taught, care should be taken, that where the ordinary teachers are not qualified, specially trained teachers should be employed." In respect to technical schools they say, "These schools, which should be the crown and development of elementary education, should be in touch and close sympathy through their management with our elementary school system."

IV. The proposals of the new Code also fall far short of what the principal School Boards are attempting. Spirited efforts are made in Birmingham, Manchester, Sheffield, Brighton, and other provincial towns, in establishing higher elementary schools with useful scientific teaching. The London Board determined from the commencement that object-lessons leading up to science subjects should be given in all its schools. It has repeatedly contended for the official recognition of such lessons; and it has lately sent a memorial to the Education Department asking that the regulation, at present in force in the infant schools, that, in assessing the grant, regard should be had "to the provision made for simple lessons on objects and on the phenomena of Nature and of common life," should be extended to the boys' and girls' departments.

The reforms decided upon by the London Board last year with the view of making the teaching more experimental and practical, and not so much a matter of book-learning as a development of intelligence and skill (see NATURE, vol. xxxvii. p. 577), are being gradually put into operation.

It has also for some years carried on a few classes for manual instruction in the use of tools with good success, but its efforts in that direction have been nearly paralyzed by the disfavour of the Legislature. This seems a necessary step towards the technical education which is now loudly called for (see Sir Henry Roscoe's lecture, NATURE, vol. xxxviii. p. 186); but in the new Code we look in vain for a word of encouragement.

Some of the larger Boards have carefully provided good instruction in natural history, and in the fundamental principles underlying mechanical, physical, and chemical science, for their pupil-teachers, though that does not appear upon the Government schedule.

V. What is wanted is a far more liberal recognition of the claims of science in elementary education. At present, object-lessons or certain sciences are, no doubt, recognized by the Code; but it is merely as an additional subject of instruction not comparable with the literary subjects which are considered essential, and which occupy the great bulk of the scholars' time. The knowledge of Nature is, in fact, totally neglected in hundreds or thousands of elementary schools, especially in country districts, where it would appear to be even more important than in towns. A boys' or girls' school can obtain the highest credit in the inspector's report, and the highest possible grant of money, without its scholars having ever heard of animal or plant, or of those materials of the world, or of those natural forces, with which the scholars will have to deal all through their lives. And what is perhaps still more anomalous, those pupil-teachers who are possibly expected to give object-lessons in their schools are never examined in natural history by the Department, and may gain a high place in their examinations without the least knowledge of any kind of natural science.

It seems most desirable that every little child who enters our schools should be led to observe and inquire; its curiosity and activity should be encouraged and directed; only when its senses have been made acquainted with things should it be introduced to the words by which they are called, first orally, then in writing or print. It should proceed from the concrete to the abstract, The works of the Creator are as worthy to be studied as the words of men, and should hold as high a place in any school curriculum.

The reply of the Department to such requests as these will probably be, We cannot assume that the teachers are capable of teaching or the inspectors of examining science. No doubt there is that difficulty. But many of them are capable, and they are all presumably intelligent men, who would easily learn what might be required of them. Special teachers of science also exist, and special examiners might be appointed. It may not be possible to insist on all these reforms at once, but at least encouragement should be held out to them, instead of the disappointing uncertainties of the Code now before Parliament.

J. H. GLADSTONE.

THE NATIONAL SCIENCE MUSEUM.

IT is now fifteen years since the Duke of Devonshire's Commission, in its fourth Report, made the following recommendations:—

"With regard to *the Scientific Collections of the South Kensington Museum*, we recommend:

"9. The formation of a collection of physical and mechanical instruments; and we submit for consideration whether it may not be expedient that this collection, the collection of the Patent Museum, and that of the Scientific and Educational Department of the South Kensington Museum, should be united and placed under the author ty of a Minister of State.

"With regard to *Provincial Museums*, we recommend:

"10. That, in connection with the Science and Art section of the Education Department, qualified naturalists be appointed to direct the collection of specimens in order to supply whatever deficiencies exist in the more important Provincial Museums; and also in order to organize typical museums, to be sent by the Department of Science and Art into the provinces to such science schools as may be reported to be likely to make them efficient instruments of scientific instruction.

"11. That a system of inspection of Provincial Museums be organized with a view of reporting on their condition, and on the extent to which they are usefully employed, and whether the conditions of the loan or grant from the Department of Science and Art have been fulfilled."

It is quite in accordance with the general way in which scientific matters are treated by the British Government that practically nothing has been done to give effect to these recommendations. Committee after Committee has been appointed, but it would seem more to give an excuse for delay than anything else. But the apathy of the Government was not shared by H.M. Commissioners for the Exhibition of 1851, for some time afterwards they offered a large site on their estate, and a building to be erected at a cost of £100,000, if the Government would undertake its maintenance for the purposes named in the recommendations. Even this munificent offer was declined.

Again we hear that another Committee has been appointed. Its sailing orders are not known, but whatever they may be, it seems desirable to again place on record after an interval of fifteen years that part of the Report in question which relates to the inquiry intrusted to the Committee. The Report was the result of much and patient inquiry and deliberation (the Commission worked for five years), and that the competence of the Commission may not be doubted after this lapse of time, we give the names of the Royal Commissioners: the Duke of Devonshire, Sir John Lubbock, Sir James P. Kay-Shuttleworth, Dr. W. Sharpey, Prof. T. H. Huxley, Prof. G. G. Stokes, Prof. Henry J. S. Smith, and Mr., now Sir, Bernhard Samuelson. Mr. J. Norman Lockyer was the secretary of the Commission.

THE COLLECTIONS AT SOUTH KENSINGTON.

64. The South Kensington Museum is administered by a Director who is responsible to the Lords of the Committee of Privy Council on Education.

65. Though, from special circumstances, the art collections of this Museum have been, up to the present time, most developed, it has contained, from its earliest days, several collections of a scientific nature. Those at present existing are:—

(1) The food collection.
(2) The animal products collection.
(3) The structure and building materials collection.
(4) Models of machinery, ships, and military and naval appliances.
(5) Collections illustrating economic entomology and forestry.
(6) Collections illustrating fish culture.
(7) The educational collections.
(8) The Patent Museum.

66. *The Food Collection.*—This collection, which was commenced in 1858, has been formed with a view to showing, first, the chemical composition of the various substances used as food; secondly, the sources from which all varieties of food are obtained; and, thirdly, the various substances used for adulteration, and the best methods of detecting them.

A duplicate collection of the chemical analyses of food is used for circulation among country schools, and large descriptive labels are supplied to the managers of country museums who may apply for them.

67. *The Animal Products Collection.*—This collection was established by the Commissioners for the Exhibition of 1851, who observed that, whilst the public possessed, in the Museums of Kew and Jermyn Street, collections illustrative of the economic applications of mineral and vegetable substances, there was no representation of the uses of the animal kingdom. The collection consists of animal substances employed in textile manufactures and clothing; substances used for domestic and ornamental purposes; pigments and dyes yielded by animals; animal substances used in pharmacy and in perfumery; and the application of waste matters, together with illustrations of the processes of manufacture.

We have been informed that, for want of space, this collection has been but little developed of late years.

68. *Construction and Building Materials Collection.*—This collection had its origin in a large number of models and specimens which were presented to the Commissioners for the Exhibition of 1851 at its close. In 1859 the collection had become so extensive from gifts, especially from the Exhibitions in London and Paris, that the classified Catalogue formed a most useful book of reference on the subject, and was largely sold as such.

The collection consists of the following objects:—building stones; marbles and slates; cements and plasters; bricks of every description; tiles for roofing, flooring, and wall decoration; terra-cottas; drain-pipes; asphalte and bitumen; iron and metal work; woods applicable to building purposes; glass, and its application; models of buildings and construction; paper-hangings; *papier-mâché* work; architectural drawings and plans.

69. In connection with this Museum, numerous experiments on the strength of materials have been carried on, the results of which have been published in the Catalogues.

70. *Models of Machinery, Ships, and Military and Naval Appliances.*—This collection consists principally of models of marine engines, ships, and guns. But there are also specimens and models of machinery of a different character, such as the Jacquard loom, the Whitworth measuring machine, and the Babbage calculating machine.

71. *Collections illustrating Economic Entomology and Forestry.*—A collection of economic entomology is now in course of formation. It is intended to enable the public to distinguish insects injurious to man from those that work to his advantage, and to illustrate the best means of destroying those which are injurious, or of mitigating the ravages committed by them.

This collection, in its relation to forestry, contains specimens of the various kinds of timber attacked by insects, the insects themselves in various stages of growth, and the appearance of the foliage and bark when attacked. The best known means of destroying the insects are also indicated.

72. *Collection illustrating Fish Culture.*—This collection illustrates the artificial breeding of fish, the protection of rivers, methods of capture of fish, &c. All or nearly all the collection belongs to Mr. Buckland (Inspector of Salmon Fisheries). It is on loan to the Museum.

73. *The Educational Collections.*—These collections comprise: (1) a library of books bearing on education in which education in science is largely represented; and (2) a collection of school furniture and fittings, philosophical instruments, apparatus for scientific and other instruction, specimens and diagrams of natural history, including mineralogy and geology, and other educational appliances, such as drawing materials, &c.

74. The origin of the library and collections is due to an Educational Exhibition formed by the Society of Arts, and held in St. Martin's Hall in the summer of 1854. When this Exhibition closed, many of the contents, English and foreign, were placed by the exhibitors at the disposal of the Society, and a strong desire was expressed that it should become a permanent institution. The collection thus formed was offered to and accepted by the Government.

75. The chief manufacturers of educational appliances and publishers of school books have largely contributed, and numerous gifts have been received from foreign Governments, especially at the close of the Exhibitions of 1862 and 1871. In consequence of the great demand for educational works on scientific subjects, the vote for purchases has of late years been largely expended in strengthening the library and collections in this direction.

76. Special collections of apparatus for teaching the various branches of science have lately been formed. Duplicate sets of these are circulated in the country.

77. The total number of books and pamphlets in the library exceeds 30,000.

78. A reading-room, ill-adapted and much too small for the purpose, as it has been stated in evidence, is attached to the library. It is open during the same hours as the Museum, and is chiefly frequented by students, teachers, clergymen, school-managers, and others who wish to consult special books, or to become acquainted with the best educational works on the various subjects.

79. *The Patent Museum.*—In connection with the South Kensington Museum, but under the control of the Commissioners of Patents, there is also a Patent Museum, consisting of a collection of patented and other inventions, ill-accommodated in a building which is much too small for the proper display of the objects. The collection belongs partly to the Commissioners of Patents, partly to the Commissioners for the Exhibition of 1851, and partly to private persons: it contains many most interesting specimens, especially a series illustrating the history of the steam-engine from its earliest days.

Proposed Additions to the Scientific Collections of the South Kensington Museum.

80. We consider it our duty to point out the striking contrast afforded by the British Museum collections, dealing with biology, geology, and mineralogy; the Jermyn Street collections, dealing with geology (scientific and economic), mineralogy, mining, and metallurgy; the Kew collections, dealing with botany, on the one hand; and, on the other hand, the collections in the Scientific Department of the South Kensington Museum (including the Patent Museum), where alone has any attempt been made to collect together, in a Museum, objects illustrating the experimental sciences.

81. While it is a matter of congratulation that the British Museum contains one of the finest and largest collections in existence illustrative of biological science, it is to be regretted that there is at present no national collection of the instruments used in the investigation of mechanical, chemical, or physical laws; although such collections are of great importance to persons interested in the experimental sciences.

82. We consider that the recent progress in these sciences, and the daily increasing demand for knowledge concerning them, make it desirable that the national collections should be extended in this direction, so as to meet a great scientific requirement which cannot be provided for in any other way.

83. The defect in our collections to which we have referred is, indeed, already keenly felt by teachers of science. If a teacher of any branch of experimental science wishes to inspect any physical instrument not in his possession, as a teacher of literature would a book, or a teacher of biology would a specimen, there is no place in the country where he can do it.

84. We are assured by high authorities that, on the Continent, collections of scientific apparatus, when combined with lectures accessible to workmen, have exerted a very beneficial influence on the development of the skill of artisans employed in making such instruments.

85. Lord Salisbury, in evidence before us, has stated:—

"There is another point in which I think that the Government might give an advantage of an educational kind to scientific research. It would be desirable, if it were possible, to provide the means of giving scientific instruction to instrument makers. My impression is that their importance to the conduct of scientific research is scarcely sufficiently recognized by the public, and that it is, I will not say quite, but almost of equal importance, to have highly educated and cultivated scientific instrument makers, as to have highly educated scientific thinkers."

86. A valuable part of the instruction to which Lord Salisbury refers would be derived from the examination of collections in which the history and latest developments of each instrument could be studied with a view to its improvement or modification in any particular direction.

87. On this point we have received interesting evidence from Colonel Strange:—

"What is your opinion as to the need of a museum of scientific instruments, and apparatus, and machines, and tools used in the arts?—I think that that is a very important branch of the subject indeed. I need scarcely allude to the great importance that is attached to that on the Continent. The name of the Conservatoire des Arts et Métiers will suggest it at once, which is the very best evidence indeed that I could produce. I have often visited it with great interest and profit. Moreover, I believe there are several others in Paris, some of more recent establishment, of the same kind; I look upon that as a most necessary part of any scientific system. No scientific system can be complete without examples of the apparatus that are being used in all branches of science, both in England and abroad, and on that point I speak from experience of the great use that such a museum would be. . . . If there were a great museum, such as I suggest, containing all the new developments in instruments, and in machines and tools, to which I could resort, I should be able to introduce modifications with far greater confidence, and it would be an enormous assistance to me individually. I find very few persons who have really studied what I will venture to call the physiology of instruments and apparatus, and such persons would derive very great advantage, I think, from being able to go to an establishment where large collections of apparatus of different dates and the products of different minds were collected together in one view, some of which would contain some desideratum of which they were in search. I think, if they had such a collection to go to, it would materially aid them in the choice of the apparatus that they required, and would tend enormously to advance exact experiments. There is no doubt that some years ago there was no nation that could compete at all with England in such matters, but we have taught the rest of the world, and the pupil has now become somewhat in advance, in many directions, of his master. Also the spread of scientific education on the Continent has tended to the application of more sound principles of construction in such things than with us."

88. Although the question of the establishment of a Museum of Scientific Apparatus is more closely allied to the objects of our Commission than that of a Museum of Mechanical Inventions, we think it right to call attention to the proposals made by a Committee of the House of Commons appointed to report on the Patent Office Library and Museum.

89. That Committee gave, in the following terms, their conception of the nature of the "General Museum of Mechanical Inventions," the establishment of which they contemplated:—

"It appears to your Committee that the chief purpose of a General Museum is to illustrate and explain the commencement, progress, and present position of the most important branches of mechanical invention; to show the chief steps by which the most remarkable machines have reached their present degree of excellence; to convey interesting and useful information, and to stimulate invention."

90. With regard to the funds which would be necessary for the establishment of such a Museum on an adequate scale, the Committee, referring to a large sum which had accumulated from the fees paid by inventors (which fund, at the end of the year 1871, amounted to £923,741 8*s.* 11*d.*), stated that—

"Your Committee consider that the principal object of the fees payable under the provisions of the Patent Law Amendment Act, was to provide for the proper working of that measure, and not for the purpose of increasing the general revenue of the country. Without entering upon the question whether or not a claim exists to have the surplus exclusively devoted to the purposes of the Act of 1852, your Committee are of opinion that for the future the annual surplus revenue accruing from the operation of that Act should be so applied to the extent which may be necessary."

91. We agree with the Committee as to the general character of the objects to which the fund in question should be appropriated.

92. We consider that this fund, which is derived in great part from the applications of scientific principles to various uses in the arts and industries of the country, would be very properly spent in bettering some of the conditions on which invention and discovery depend: and we are of opinion that, among the uses to which such a fund could be most advantageously applied, the establishment of such a Museum of Scientific Apparatus as that which we contemplate would rank among the most important; and we are convinced that such a Museum would have a material influence upon the spread of scientific instruction throughout the country, and would therefore largely foster invention and discovery.

93. We accordingly recommend the formation of a collection of physical and mechanical instruments; and we submit for consideration whether it may not be expedient that this collection, the collection of the Patent Museum, and of the Scientific and Educational Department of the South Kensington Museum, should be united and placed under the authority of a Minister of State.

94. Whether this union be effected or not, we are of opinion that it is desirable that the scientific collections now placed at South Kensington should be subjected to a critical revision, with a view to restricting them to such objects as are of national interest or utility.

REPTILIAN ORDERS.

Catalogue of the Chelonians, Rhynchocephalians, and Crocodiles in the British Museum (Natural History). By G. A. Boulenger. New Edition. Pp. 311, Illustrated. (London: Published by the Trustees of the Museum, 1889.)

THE handsome volume before us deals, as its name implies, with all known existing forms of the three Reptilian orders of the Chelonians, Rhynchocephalians, and Crocodilians; but since the second group is represented only by a single species, while the number of Crocodilians comprises little more than a score of forms, the great bulk of the book is devoted to the Chelonians, and it will, therefore, mainly be this group to which our remarks will apply.

Previously to the appearance of this volume, the last systematic "Catalogue of Crocodilians and Rhynchocephalians" issued by the Museum was the quarto volume by the late Dr. Gray,[1] published in 1872; the next year having seen the publication of the revised list of Chelonians by the same author.[2] Without in any way wishing to disparage the labours of the late Keeper of the Zoological Department, to whose untiring energy the British Museum is so greatly indebted for its magnificent series of Reptiles, it is at once manifest that the present work is enormously in advance of any hitherto published, this advance being especially noticeable in the case of the Chelonians. Although in that order Dr. Gray figured a large number of skulls, yet the distinctive features afforded by this part of the skeleton were not accurately gauged from a taxonomic point of view, while the characters of the bony carapace, so far as they relate to the connections of the component bones with one another, were practically ignored. In this respect Mr. Boulenger has conferred a great boon, not only on the students of the Chelonia of the present day, but still more especially on those engaged in the study of fossil forms, who generally have to deal only with the more or less imperfect carapace and plastron. In almost every genus the author has caused at least one specimen to be stripped of its epidermal horny shields, so as to exhibit not only the impressions formed by the borders of these shields, but also the form and relations of the underlying bones which constitute the solid shell. And he has found that generic characters can be to a very large extent based on the structure of the skull, taken together with the form and relations of the bones of the shell; the contour of the neural bones of the carapace, and the relations of the suture between the humeral and pectoral shields of the plastron to the entoplastral bone being of especial importance. No less than seventy-three admirably-executed woodcuts serve to illustrate these osteological features, on which the taxonomy is so largely based; and by their aid the palæontologist may hope to clear up to some extent the affinities of the host of fossil Chelonians at present described under the vague terms of *Emys* and *Clemmys.*

The author proposes to divide the Reptiles treated of

[1] "Catalogue of Shield-Reptilia. Part 2. Emydosaurians, Rhynchocephalia, and Amphisbænians." (1872.)

[2] "Hand-List of the Specimens of Shield-Reptiles." (1873.)

in this volume into the following groups of higher than generic rank, viz.:—

Order **Rhynchocephalia.**
Fam. Hatteriidæ.

Order **Chelonia.**
Sub-order I. ATHECÆ.
Fam. 1. Sphargidæ.
Sub-order II. THEOCOPHORA.
Super-fam. A. *Cryptodira.*
Fam. 2. Chelydridæ.
3. Dermatemydidæ.
4. Cinosternidæ.
5. Platysternidæ.
6. Testudinidæ.
7. Chelonidæ.
Super-fam. B. *Pleurodira.*
Fam. 8. Pelomedusidæ.
9. Chelydidæ.
10. Carettochelydidæ.
Super-fam. C. *Trionychoidea.*
Fam. 11. Trionychidæ.

Order **Emydosauria.**
Fam. Crocodilidæ.

There are a few points in regard to the nomenclature of some of these groups where the author's views are at least open to question. This is especially the case with regard to the selection of the name Emydosauria to replace the almost universally accepted Crocodilia. The reason for the selection of this term appears to be, that it is the earliest. In common, however, with a large number of English zoologists, we (while deprecating the needless introduction of new ordinal names) hold that, although the enforcement of the rule of priority is, unfortunately, in most cases, obligatory as regards generic and specific names in order to avoid endless confusion, yet no such rule is necessary in respect to higher groups, where the name that has come to be generally used ought to be maintained. Then, again, the ungrammatically formed name Athecæ, for which Prof. E. D. Cope is responsible, should clearly have been amended to Athecata; while, since the name Thecophora—or, more correctly, Thecaphora—clashes with the same term employed for a group of Hydroid Zoophytes, we think the author would have been better advised had he followed his own article on Tortoises in the latest edition of the "Encyclopædia Britannica," and employed the term Testudinata in this sense. Finally, since the generic names *Hatteria* and *Sphargis* are rejected in place of the earlier *Sphenodon* and *Dermochelys* (which, by the way, should clearly be amended to *Dermatochelys*), we cannot follow the author in retaining the names *Hatteriidæ* and *Sphargidæ* for the families respectively represented by these two genera. If a family name means anything at all, it means a group of animals more or less nearly allied to a certain genus selected as the type, and it is therefore clearly illogical to call the *Sphenodon*-like reptiles *Hatteriidæ* when no such genus as *Hatteria* exists. Further, to show the absurdity to which this adherence to the rule of priority, in place of that of common-sense, in the case of family names might lead us, we have only to suppose that the name *Hatteria*, in place of being rejected as later than *Sphenodon*, had been rejected on account of being preoccupied by another form belonging to, but not the type of, a distinct family. In such case, we should have the family name *Hatteriidæ* for a group of animals which did not include the genus *Hatteria!* On these grounds we hold that the names *Sphenodontidæ* and *Dermatochelydidæ* should certainly replace *Hatteriidæ* and *Sphargidæ*.

In regard to the Rhynchocephalia, the author considers that its one existing representative indicates an extremely generalized type of reptile, of which the relations appear to be at least as close to the Chelonia as to the Lacertilia. In this respect, Mr. Boulenger departs very widely from the views of Prof. Huxley; and although we think he is undoubtedly justified in maintaining the Rhynchocephalia as a distinct order, yet we cannot overlook the circumstance that the Homæosaurian lizards of the Lithographic stone, which appear to be Rhynchocephalians, are most probably closely related to the ancestors of the Lacertilia.

The whole of the existing Crocodilians are included in a single family—against the three families adopted by Dr. Gray. The true Crocodiles are divided into *Crocodilus* and *Osteolæmus*, according to the absence or presence of a forward prolongation of the nasals to divide the anterior nares; while among the Alligators a similar feature serves to distinguish *Alligator* and *Caiman*. The *Crocodilus pondicerianus* of Gray is considered to be based upon a young specimen of *C. porosus*. The Gharial skull mentioned on p. 276 as having been obtained at Poonah would appear to be incorrectly labelled, as this reptile is unknown in Bombay.

Taking a brief general survey of the Chelonia, we think the author is fully justified in adopting Prof. Cope's division of the order into the two primary groups of Athecæ and Thecophora; the great difference in the structure of the skull, as exemplified by the absence of descending parietal plates in the former, being a character which is of itself apparently sufficient to uphold this division. We are aware, indeed, that Dr. G. Baur, of Newhaven, Conn., holds a precisely opposite view, and, in place of regarding the *Athecæ* as the most generalized type of existing Chelonians, looks upon them as an extremely specialized branch derived from the Cryptodiran *Chelonidæ*. There are, indeed, certain superficial, and probably adaptive, resemblances between these two types of marine turtles, but the fundamental differences are so great as apparently to render Dr. Baur's views untenable. And we should much like to ask that authority how he would explain the appearance of transverse processes to the dorsal vertebra of one of the extinct Athecæ on his own hypothesis of their phylogeny.

The three "super-families" into which the Thecophora are divided are, to a great extent, distinguished by the mode of flexure of the neck, by cranial characters, and by the relations of the pelvis to the shell. Certain very peculiar features in relation to the mandibular articulation, the tympanic ring, and the arrangement of the bones of the palate serve to distinguish the existing Cryptodira of the southern, from the Pleurodira of the northern hemisphere; but we have considerable doubts whether these characters will be found to obtain in the Mesozoic representatives of the group, and whether they are not rather acquired than archaic features. We should, indeed, have been glad to have an expression of the author's views as to the mutual relations from a phylogenetic point of view of the three groups of the Thecophora; because, if the separate nasals and parieto-squamosal arch of some of the Pleurodira be indicative of their more primitive organization, it would be pretty clear that the peculiar specialized character of the mandibular articulation can only be diagnostic of the later forms.

The Trionychoidea, or soft Tortoises, appear to show affinities to the Pleurodira in the structure of the palate; and here again we miss an expression of opinion as to the nature of this relationship. The peculiar chevron-shaped entoplastron, which is regarded as an important diagnostic feature of the group, was, we believe, first brought prominently to notice by Dr. Baur.

In regard to the families of the Cryptodira, the author follows Dr. Gray in regarding *Staurotypus* as nearly related to the *Chelydridæ*, but places it in a distinct family, of which *Dermatemys*, placed by Dr. Gray next the Batagurs, is taken as the type. *Cinosternum*, likewise placed by Dr. Gray in the *Chelydridæ*, is regarded as the type of another family, readily characterized by the absence of the entoplastral bone; while the *Platysternidæ* is likewise a family of which but one genus is known. The widest departure from the arrangement of Dr. Gray is, however, found in the case of the *Testudinidæ*, which is a very extensive family, embracing the *Emydidæ* of other writers, and no less than four other families of Dr. Gray's "Hand-List." The transition from one genus to another is, however, so gradual, as apparently to afford full justification for the new departure. Twenty genera of this family are recognized, all of which can be defined by characters of the skull and shell. We would especially note the disappearance of the well-known *Pangshura* of India in the genus *Kachuga;* and would also remark that, after its complex synonymy, the common European Pond Tortoise is finally to be known as *Emys orbicularis*. The genus *Testudo* is the largest in the whole order, comprising no less than forty-one species. Here it has been found that the division of the pygal, or supra-caudal, shield is a character commonly occurring in the typical *Testudo græca*, and consequently *Testudo emys*, which, on this account was made the type of the genus *Manuria*, and has attained an unfortunate notoriety owing to the controversy regarding *Scapia*, is included in the type genus. The *Chelonidæ*, or Turtles, are divided into the genera *Chelone* and *Thalassochelys*, each of which is represented by two species. And here we may notice the wise discretion of the author in refusing to recognize a host of so-called species based on features which may well be regarded as merely indicative of varieties. The members of this family, it may be remarked, are the only existing Thecophora in which the temporal fossæ are completely roofed over by bone; and since a more or less complete approximation to this feature occurs in many Mesozoic types, this bony roof may perhaps be regarded as indicative of direct affinity with some of these early types. In the Pleurodira the first two families are distinguished from one another by the presence or absence of a mesoplastral bone, as well as by well-marked cranial features, while the third family, represented only by the aquatic *Carettochelys* of New Guinea, has no epidermal shields on the shell. This remarkable form, it may be observed, is one of the few desiderata in the collection of the Museum.

In the Trionychoidea, all of which are included in the family *Trionychidæ*, the author has, we believe for the first time, pointed out characters by which the skull of the typical forms, in which the hyoplastral remains distinct from the hypoplastral, can be readily distinguished from that of the group typically represented by *Emyda*, and characterized by the fusion of the above-mentioned bones. In the diagnosis of the genera *Trionyx*, *Pelochelys*, and *Chitra* on p. 241, we meet with the following sentence, viz. "outer extremities of the nuchal bone overlying the second dorsal rib." This sentence, when contrasted with the corresponding diagnosis of the three following genera, strikes us as liable to lead to confusion; and the sentence would be better if it read "outer extremities of the nuchal bone overlying the rib supporting the first costal bone." It appears, indeed, that the first dorsal rib of Chelonians is aborted, and carries no costal bone, or plate, so that the first costal bone is supported by what is really the second rib. We may perhaps be pardoned for pointing out that the term "*straight* angle," mentioned in the fifth line from the bottom of p. 251 does not, at first sight, suggest the idea of a "*right* angle," for which, we presume, it is meant.

Scarcely any systematic work can nowadays escape criticism, but in our judgment the system adopted in the present volume appears to be one which in the main ought to meet with very general acceptation, and we heartily congratulate the author on the completion of a very laborious task in a manner which deserves the thanks of the students both of recent and fossil Chelonians. R. L.

THE HISTORY OF ANCIENT CIVILIZATION.

The History of Ancient Civilization. By the Rev. J. Verschoyle, M.A. (London: Chapman and Hall, 1889)

THE title of this book is somewhat misleading. One is led to expect from it a history of the growth of civilization from its earliest stages to its various developments among different nations or races, and of the relation of one form to another. But instead of this we have an account of the characteristic civilization of certain selected nations when at their best, with very little to indicate any relation between them. The nations whose civilization is described are the Egyptians, the Babylonians, and Assyrians; the Jews, Phœnicians, Aryans, and Persians; the Greeks and the Romans. The two latter are treated very fully, occupying about three-fifths of the whole. There can be no question that the information conveyed would be very useful to a student of ancient civilization, but he would immediately ask for more. If he had any intention of studying the question from a scientific point of view, he would not be content with isolated facts, but ask for the connection between them. Indeed, one of the most conspicuous features of the book is the complete absence of any scientific method; its merits must be appreciated entirely from the literary standpoint, especially in connection with the history and literature of Greece and Rome.

In any scientific history of civilization, the first stages, in which from rough stone implements men passed to the arts of drawing, sculpture, and the manufacture of pottery, and so to the invention of bronze and the erection of megalithic buildings, are surely of too much interest to be dismissed in a sentence or two, with an illustration of a "flint spearhead" of very peculiar appearance. To what races these men might belong we do not learn from our author, who, after observing that "modern science has also directed its attention to the subject of races and anthropology, and has issued in studies which have not, however, yet resulted in a decisive conclusion," dismisses all other races in eighteen lines, and springs on us the "white race," "whose first habitation was the highlands of Asia." "It was there that, after the deluge chronicled in the legends of all Eastern nations, mankind dispersed, and formed the three chief branches of the white race—the families of Ham, Shem, and Japhet." Thus we learn nothing about the remarkable and early civilization of the Chinese, on the ground that "the information respecting it is not sufficient." We are not, therefore, surprised that the author dismisses America with the single sentence, "In America, the copper or red race has continually receded before the Europeans, and cannot be counted amongst the civilized races." He apparently thinks there has never been but one race in America, and forgets the ancient civilization of the Aztecs, and that of the race which they themselves succeeded; and we cannot therefore hope that he will throw any light on the home of that remarkable people who carved the idols of Easter Island, or erected the megaliths of Tonga.

In the chapter on Egypt there is much interesting though somewhat disconnected information; but those who think that the arts and sciences are amongst the most important parts of civilization, will perhaps scarcely be satisfied with the statement that "the scientific theory, which would consider the pyramid a kind of observatory, is quite unfounded."

The materials for the description of the civilization of the cities of Mesopotamia are so rich that the chapter which deals with it cannot fail to be interesting; it is only to be desired that the relations of the Accadians, Babylonians, and Assyrians, and their several conditions, had been made more clear, and the great length of time, as in the case of the Egyptians, over which the same type of civilization continued, pointed out. Indeed, one of the remarkable features of ancient civilization, which has an important bearing on the antiquity of man, is its slow progress.

The account of Eastern civilization, or that of the Aryans and Hindus, is very defective. Indeed, we have little more than a short account of the tenets of Brahmanism and Buddhism, and no mention of their art, though many of the Hindu stupas and topes date back before the Christian era. There is some fair description of Persian and Phœnician civilization, but there is nothing about the Phrygians. The rock tombs of Asia Minor are unnoticed, and Troy is only mentioned in relation to the Greeks.

In contradistinction to this, the treatment of Grecian and Roman history is superabundantly full, as one sentence will show. "The 'epithalamium' of Mallius is probably his best work, always excepting his charming lyrics to Lesbia." If a notice of so little known a poet forms part of the history of ancient civilization, it is difficult to see why the omissions above enumerated should occur.

In a word, the whole subject is unequally treated; there is a bias towards classical learning, which, in spite of the useful information given, prevents the book from being in any sense a scientific history.

OUR BOOK SHELF.

Board School Laryngitis. By Greville Macdonald, M.D. Lond., Physician to the Throat Hospital, Golden Square. Pp. 31. (London: A. P. Watt, 1889.)

NUMEROUS as are the evils to which the Board School system is alleged to have given rise, we have before us yet another indictment to add to the list. This time, however, it is the teachers, and not the scholars, who compel our interest. Dr. Macdonald claims to have identified certain changes in the vocal apparatus of Board School teachers, of both sexes, of so definite a character as to enable him to state with certainty from the appearance of the throat that the patient belongs to that long-suffering class.

A varicose condition of the superficial vessels of the vocal cords and a nodular hypertrophy of the free margins are the conditions to which he calls special attention. Of the latter condition he notes that it may occur without obvious inflammatory surroundings, and quotes Stoerk's reference to it under the name of "singers' nodules." He does not, however, mention the Viennese laryngologist's explanation of them, which, in the present connection, is interesting. Stoerk claimed that these nodules were the direct result of an improper use of the voice, whereby a part only of the vocal cords was set in vibration. The nodules made their appearance at the spot intervening between the vibrating and the motionless parts of the cords, usually the junction of the anterior third with the posterior two-thirds.

Board School teachers, uninstructed for the most part as to the use of the voice, depressed by the close and often foul atmosphere of a crowded schoolroom, choked with the chalk from their blackboards, and often compelled to scream to make themselves heard above the din of an unruly class, are beset with every condition which predisposes to inflammation and over-straining of their vocal apparatus.

Dr. Macdonald suggests remedies for such a state of things, for the consideration of the ruling powers, and intimates that local treatment alone is of any avail in dealing with the changes to which he calls special attention. The varicose vessels he would destroy with the galvano cautery, and the nodules with the forceps. The monograph is written in a fluent and readable style, and treats of a subject which deserves the serious attention both of lay and professional readers. Possibly the interest of the latter class would have been more keenly aroused had the author appended a little more information as to the extent of his experience. He tells us that the Board School teachers consult him in increasing numbers, and that his success in treatment has been remarkable, but he does not quote cases, or offer any statistical record, by which his professional brethren may compare his experiences with their own in the same line of practice.

The pathological conditions to which he would affix such an attractive title are not by any means unknown as a consequence of chronic laryngitis in other walks of life, and something more than mere assertion must be offered before they can be generally accepted as the peculiar product of the Board School system.

E. CLIFFORD BEALE.

A Treatise on Elementary Algebra and Algebraical Artifices. By Saradaranjan Ray, M.A. Two Vols. (Calcutta: S. K. Lahiri and Co., 1888.)

THE work under review is also Part II. of "A Course of Elementary Mathematics." Vol. I. comprises those portions of elementary algebra usually to be found in modern text-books up to the chapter on proportion. Vol. II. includes chapters on variation, theory of equations, elimination, binomial theorem, and properties of logarithms, as well as many others; but those mentioned will suffice to show the general scope. The author gives the object he has had in view: "To create in beginners a taste for algebra, and to show them the utility and application of algebraical artifices." In achieving this desire he has met with some degree of success. The language employed is simple and clear. The proofs in many instances are interesting. We question the advisability of placing the binomial theorem and properties of logarithms at the conclusion of a work which contains biquadratic equations. At least an elementary chapter upon the former subject should precede the theory of equations, while a discussion of logarithms would be of great use in its development.

We notice one very important omission: the multinomial theorem finds no place in these volumes. This is much to be regretted, for the chapter on permutation could have introduced it in an elegant and suggestive manner. Again, we notice that the subject of series is scarcely touched upon. One would hope in a work of this scope to find a short chapter which would include reversion of series. However, there are many excellent features in the book. Chapters on "Consistency and Sufficiency," and on "Identities and Equalities," are novel and gratifying. The pages concerning arithmetical and geometrical progressions are original and inspiring; for example, the student is taught the meaning of the sum of n terms of a progression when n is negative, and is shown that both arithmetical and geometrical progressions possess the common property that two successive terms are connected by a linear relation; from this point of view the series are then further examined.

There are many examples, as a rule well selected, with occasional hints to show the learner that a little ingenuity will often overcome particular difficulties. There are a few occurrences of faulty printing, and some misprints which do not appear in the errata.

The students of our Eastern dependency are in possession of a book by one of their own countrymen who is a thorough master of his subject.

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 Sailing Flight of the Albatross.

IN NATURE, vol. xxxix. p. 230, the late Mr. William Froude, in a letter to Sir William Thomson, on the subject of the "Soaring of Birds," gives a short account of the well-known and often discussed sailing flight of the albatross; and says that after long consideration the only explanation which presented itself to his mind was, that the birds use the upward current caused by the lifting of the air from the bottom of the trough to the level of the crest of an advancing wave. Mr. Froude by a rough calculation—the waves being supposed 10 feet from hollow to crest—concludes that an upward current of 3 feet per second may be caused in this manner, and states that the bird's movements were often in accordance with this explanation, though it was often impossible to affirm or deny the accordance.

Having had many opportunities of observing the flight of the albatross, I cannot think this explanation the true one. I have often seen albatrosses sailing when the sea appeared as flat as a table, with the exception of the small waves caused by a light wind. This seems fatal to Mr. Froude's explanation, which requires waves of considerable size. As Mr. Froude observed, the birds often sail along the crests of waves. It seemed to me that they were sometimes using the current diverted upwards by the wave, just as on land birds use that diverted by hedges, river-terraces, &c.

I will first give a description of the flight of these birds, as I observed it when on board steamers running between Australia and New Zealand, which are nearly always followed by numbers of birds; and then attempt an explanation. The sailing flight is never to my knowledge done in a calm. I once observed the effect of a gradually diminishing wind on their flight. The steamer was going about nine knots. When the wind, which was very nearly aft, became one or two knots slower than the steamer, the birds, which had hitherto kept their wings perfectly steady, began to flap at intervals which became shorter as the wind lessened, and when it ceased they flapped almost without intermission, and soon ceased to follow the vessel.

The birds go through a series of movements which are related to the direction of the wind. Starting from near the surface, they rise in a slanting direction against the wind, to a height which varies with the strength and direction of the wind. The average seemed to me about 20 feet. Then comes immediately a turn half round in a rather large circle, followed at once by a rapid descent down the wind. They then take a longer or shorter flight in various directions, almost touching the water. After that another ascent in the same manner, and so on, repeating the series of movements *ad libitum.* The interval of time between the ascents evidently depends on the direction of the wind with regard to the course of the vessel. When the wind is ahead, and the birds' velocity through the air great, being necessarily greater than the wind's velocity plus that of the steamer, the interval is short. When the wind is abaft the beam, and the birds' velocity much less, the interval is usually much longer. As a general rule, there is a rough proportion as to the favourableness of the wind and the length of time between successive ascents. Also, when the wind is favourable and not strong they do not rise so high as in a strong and adverse wind.

The explanation I have to give of the movements above described depends upon the well-known fact that the velocity of the wind at the surface is diminished by friction, so that its velocity increases with the height, the *rate* of increase being greatest near the surface. Prof. Osborne Reynolds found by experiment that the wind's velocity over a grass meadow at a height of 8 feet was double that at 1 foot.[1] Over the sea, when there is enough wind to roughen the surface, the drag on the lowest stratum is probably greater than over a grass meadow, on account of the motion communicated to the water. This effect of friction makes clear the object of the ascents against, and the descents with, the wind. For, as a bird rises, he enters currents of wind which increase in velocity with the height, in a direction contrary to his own motion, so that the loss of velocity consequent on rising, and which would take place in still air, is partly—or perhaps, when the wind is strong, wholly—made good. The bird thus gains energy of position, which is converted into energy of motion by descending. A bird's ascent against the wind may be compared with the ascent of a particle up an incline, while the incline itself is accelerated in a horizontal direction opposite to that of the particle's motion, thereby enabling it to reach a height greater than that due to the initial velocity. The albatross does not go on rising until his velocity is nearly exhausted, but makes a half-turn at great speed previous to his descent. Thus the quickness of the ascent, with, as Mr. Froude says, scarcely if any apparent loss of speed, is explained. By making a slanting descent with the wind, the bird carries with him the velocity of the faster-moving wind of the high level into the slower-moving wind near the surface; and thus increases his velocity through the air, to which is to be added that due to his fall. Thus, if resistance is left out of account, the bird's velocity since he began to ascend would have been increased by twice the difference in the velocity of the wind near the surface, and at the height to which he rises. And as the power of overcoming resistance varies as the square of the velocity, the addition of several feet per second to the bird's already high velocity is equivalent to much more energy than is lost in the few seconds occupied by the rise, turn, and fall;

[1] "On the Refraction of Sound by the Atmosphere," by Prof. Osborne Reynolds. Read before the Royal Society, April 23, 1874.

so that there is a clear gain, which may be expended in flight until the speed is so much reduced that it is necessary to increase it by another ascent.

The reason is clear why, when following a steamer against the wind, the birds are compelled to repeat at short intervals the movements by which speed through the air is gained, and why, when the wind is favourable, the intervals are longer. The great length of these intervals just mentioned seems to me the difficult point in the theory. It cannot be proved that the speed acquired by the movements described is sufficient for such long flights between the ascents as are sometimes seen, under conditions where there is no suspicion of upward currents near the surface. Our knowledge of the resistance of the air to such complex surfaces as the wings of birds is, I believe, almost nothing; and even if we knew, without doubt, the true explanation of the manner in which the energy lost by resistance is renewed, we might find it hard to apply it to all cases, unless we had some real knowledge of the supporting power of the air, and the horizontal resistance at different velocities.

I have sometimes seen a number of albatrosses sailing in a peculiar manner, the wind being at right angles to the course of the steamer. They ascend against and descend with the wind, turning alternately right and left, so as to describe an undulating line, not far behind the stern. A number of them sometimes do this for hours, while others are sailing in various directions farther off. It is curious that the common sea-gulls of New Zealand (*Larus dominicanus*), which have become to a great extent land-birds since the country was colonized, may be sometimes seen making their way over flat country in the same manner as the albatrosses just described—that is, at right angles to the wind, and turning alternately right and left, and nearly touching the ground at each descent. Their success in doing the sailing flight is, however, imperfect, as they seem compelled to flap their wings a few times during the second half of each ascent. Perhaps future generations of gulls may improve. No doubt some muscular exertion is saved by this mode of progression. The foregoing theory of the sailing flight of the albatross shows, I think, the action of a *vera causa*, which, as far as I know, has not been noticed before. A. C. BAINES.

Christchurch, New Zealand.

Note on *Ragadia crisia*.

MR. W. L. DISTANT, in his admirable "Rhopalocera Malayana," calls attention to the recent appearance of *Ragadia crisia* in the Malay peninsula. As I have had opportunities of studying the habits of the species in what seems to be one of its head-quarters, it may be desirable to record the facts.

Mr. Distant writes as follows:—"One of the most peculiar facts in relation to this butterfly seems to be its almost recent appearance in the Malay peninsula, or at all events its first capture there by collectors. I did not meet with it myself when collecting at Province Wellesley, nor did I subsequently receive it in numerous collections derived from the peninsula. In 1883, however, the species seems to have been common from Penang to Singapore. I first received two specimens captured on Penang Hill, and sent to me as a new species; others shortly followed from Province Wellesley, with the remark of an experienced collector that the species was quite new to the locality; and almost simultaneously the Indian mail brought me more examples from Sungei Ujong, Malacca, and Singapore. My friend Mr. Logan also sent me an example with the comment, 'a very rare butterfly not known to collectors here.'

"Capt. Godfrey, who also captured the species at Sungei Ujong, described it as being found in low undergrowth in the forest, where, especially in the early morning, I several times met with it. Its flight is weak and feeble, but it cleverly eludes pursuit by threading its way through tangled brushwood" ("Rhop. Mal.," p. 421).

Mr. W. B. Pryer, in his joint paper with Mr. Distant ("Rhop. Northern Borneo," *Ann. Mag. Nat. Hist.*, January 1887, p. 49), describes it as "rare, under almost thick forest shade." In ten years' collecting in North Borneo he has only met with a few specimens, not more than a dozen, nearly all of which he saw at Silam, on the coast of the district I write about.

I find it to be the very commonest butterfly in the dense forest of the centre of Darvel Bay Peninsula, on the east coast of British North Borneo.

I first saw the insect in the deep forest between Lamag on the River Kinabatangan and Itok Batu on the River Segama, about 120 miles inland. It was not common, but I always saw one or two daily. Since then Mr. Pryer has taken it higher up the River Kinabatangan, some 250 miles up stream. The butterfly is still quite rare on the coast, the only specimens having fallen to Mr. Pryer's net.

Last year I made an exploration through the forest from the River Tinkyo in Darvel Bay to the head-waters of the River Segama. Within four miles of the coast, in the alluvial flat of the River Tinkyo, the species was seen daily, but was far from common. As soon as we touched the mountain country it began to grow common, and from 600 feet to 2500 feet above sea-level it was the commonest butterfly in the deep forest.

Capt. Godfrey's description of its habits agrees with mine, except in one particular. He found it most plentiful in early morning. I was always in the jungle from soon after dawn to near dusk, and found it appeared about 9 o'clock in the morning, and was on the wing till about 4 o'clock in the afternoon.

It has the feeblest (and wickedest) flight of any butterfly known to me. I never saw it rise six feet above the ground, and it flaps slowly along, apparently with effort, its wings not stiff but bending with each stroke. It *looks* a certain capture; but this, as Capt. Godfrey found, is delusive and elusive. It keeps just above the low bushes from two to three feet high, and sneaks in among them most exasperatingly. It seems to do this deliberately, and will rather circuit round an opening made by a fallen tree than cross the small opening. It is often seen flying in rain.

As a rule it is quite solitary, it being rare to see two at once, and it is not at all bold or pugnacious.

Its wings are so soft that it often crumples in the wet, and it is almost impossible to set it during the rainy season, the wings relaxing in a few hours, though it may have been a week on the setting-board.

From February to October it was equally common. I then came out of the forest. It probably flies all the year round.

It is one of the few true forest species, and avoids the sunshine.

I do not know whether the insect is common elsewhere, and can offer no suggestion as to why it should be spreading from this part, though it is undoubtedly creeping coastwards. The eastern part of North Borneo is untouched primæval forest, the only clearings being on the coast and river-banks, and these are small. The country where *Ragadia* abounds is quite uninhabited, and it is difficult to see how the food-plant (unknown) could have been taken thence to the Straits Settlements. Then too, in Borneo at any rate, it would avoid clearings.

Leaving this question for future observers to solve, we now know that in one part of the interior of North Borneo *Ragadia crisia* is very common, and it is extending its area.

SYDNEY B. J. SKERTCHLY.

Spherical Eggs.

PROF. ALDIS will find references to the history of this ancient question in an article by Mr. W. Walton in the *Quarterly Journal of Mathematics*, vol. ix. p. 79, where it appears as Leslie Ellis's problem of the thirsty crow. "A thirsty crow flew to a pitcher and found there was water in it, but so near the bottom he could not reach it. Seeing, however, plenty of small, equal spherical pebbles near the place, he cast them one by one into the pitcher, and thus by degrees raised the water up to the very brim and satisfied his thirst. Prove that the volume of water must have been to that of the pitcher in a ratio not less than $3\sqrt{2} - \pi : 3\sqrt{2}$." References are supplied in the article by the Rev. Dr. Luard to Pliny's "Natural History," book x. chapter 43, "De Corvorum Intelligentiâ"; Plutarch, "De Solertiâ Animalium; and Ælian, "De Naturâ Animalium." Consult also Tait's "Properties of Matter."

Thus in an aggregation of closely-packed equal spherules the unoccupied space is $1 - \frac{1}{6}\pi\sqrt{2}$ of the whole volume.

We may verify this experimentally by comparing the weight of a given volume of small lead shot with the weight of an equal volume of lead; theoretically the densities should be as π, to $3\sqrt{2}$.

On a larger scale, the question may be studied in the piles of spherical shot formerly to be seen in our forts and arsenals. Whether we begin piling the shot in horizontal layers, in triangular order, or in square order, the internal molecular arrangement of the spheres is the same; but the square order in the horizontal layers is preferred, as it is then possible to build the pile on a rectangular base, finishing off at the top with a ridge of balls in single file, the sloping faces all showing the spheres in triangular order.

Suppose a bag, impermeable to water, is filled with lead shot, placed in an hydraulic press, and subjected to great pressure. The lead spheres will be flattened against each other in regular cell structure into a solid mass, each sphere being changed into a *rhombic dodecahedron*; and in this manner the form of the cell of the bee has been considered as arising in a natural manner by Mrs. Bryant, D.Sc., in a paper read before the London Mathematical Society, vol. xvi., "On the Ideal Geometrical Form of Natural Cell-Structure." The plane surfaces of separation also form a possible arrangement of the films of a mass of soap-bubbles; but the instability of the corners where six edges meet modifies the soap bubble arrangement to the form investigated by Sir W. Thomson in the *Acta Mathematica*.

April 27. A. G. GREENHILL.

Name for Unit of Self-Induction.

A NAME for the unit coefficient of self-induction is much wanted. No one is satisfied with secohm, and yet it seems making its way; by reason, no doubt, of Ayrton and Perry's ingenious commutating arrangement for helping to measure it. It is an unpleasing name, and it is too big a unit. The name quad, which I formerly suggested, is on further consideration still less satisfactory for permanent use, because it emphasizes unduly the accident that *in electro-magnetic measure* self-induction happens to be a length. One looks forward to the time when all distinction between electrostatic and electro-magnetic measures shall vanish by both ceasing to be; and at that not far-distant time, names emphasizing the present arbitrary state of things will be anachronisms, as well as stumbling-blocks to beginners. I beg to suggest that a milli-secohm shall be called a *vo*. It is a short and harmless unmeaning syllable not yet appropriated. It should be its own plural. The unit of conductivity is already styled a *mo*; and 8 vo will look well alongside 12 mo. "Vo-meter" is short and satisfactory. A unit of magnetic induction will then be the vo-ampere; and this, being of a size convenient for dynamo makers, may be hoped to replace their abominable mongrel unit "Kapp-lines."

The vo in electro-magnetic measure is 10 kilometres, and hence a vo ampere per square decimetre is a magnetic field of a thousand C.G.S. units, and might be called a "Gauss." For lightning-conductor work the natural unit of self-induction will be a milli-vo, or 10 metres of electro-magnetic measure.

Grasmere, April 16. OLIVER J. LODGE.

Hertz's Equations.

PERMIT me to add a line of explanation of my letter on this subject, printed in NATURE, vol. xxxix. p. 558. I intended no criticism of Hertz's general result, but merely to draw attention to the necessity of rejecting all solutions of the equation in Π which made the force (Z) infinite for points on the vibrator.

Berkswell, April 24. H. W. WATSON.

A NEW PEST OF FARM CROPS.

DURING the past three or four years, in the examination of plants affected by various injurious worms and Arthropods, and of the soils in which such plants grew, I have from time to time been led to suspect that certain small species of *Oligochæta* were concerned in damaging, if not ultimately destroying, several species of cultivated plants. With a view to converting suspicion into proof, experiments on isolated growing pot-plants have been carried on.

Within the past few weeks I have received, through the kindness of Miss E. A. Ormerod, additional evidence of a striking character, which induces me to place the main facts on record.

In the spring of 1885, Miss Ormerod forwarded to me for inspection two small white *Oligochæta*, 1½ inch long, received by her in soils from the roots of plants. In reporting on them I replied that it did not seem very probable that they could seriously injure the plants.

In April 1888, an inquiry reached me as to the nature and means of prevention of a serious attack of "small white worms" destructive to pot and green-house plants. On being placed in communication with the observer, the Rev. William Lockett, Rector of Littledean, I received from him a box of soil taken from his affected flower-pots, and much valuable information in answer to a series of questions put by me. The soil itself contained some hundreds of the white worms described; and the detailed information all pointed to these worms as the cause of many serious losses which had been sustained.

The worms were Enchytræidæ, of the genus *Enchytræus*, apparently near to *E. Buchholzii*, Vejd. I took three plants, a sunflower, a geranium, and a tradescantia, and had them re-potted in carefully examined sifted earth; when they were well established, I put fifteen of the worms into each pot, and left them to be tended by the gardener. I kept a number of the worms in soil which was alternately wetted and dried at regular intervals. They all kept alive and vigorous; when wet to complete immersion they were most active, when dried they remained quiescent, apparently dried up, and difficult to discover.

After two months, the sunflower drooped and bent over, and examination showed the roots and rootlets dead and the stem rotting. Within the decaying stem some of the Enchytræidæ were found alive and active. The other two plants are still living, but it will be shown that the number of worms supplied them was too small. Mr. Lockett lost spiræas, vegetable marrows, fuchsias, gloxinias, and many other plants, and the dead roots often contained in and around them many hundreds of worms to each plant. Both in his garden and a neighbouring ash-heap he found an abundance of them.

I was on the point of repeating my experiments this spring with various seedlings, when I received by the kindness of Dr. Gilbert, of Rothamsted (at the suggestion of Miss Ormerod), a quill with two or three specimens of worms of the same genus. Mr. John J. Willis, the superintendent of the field experiments at Rothamsted, in sending them described them as obtained from a field of clover "with a good plant except across one portion of the field, where all the plants were dying off," the small worms occurring at the roots of the clover along with larvæ of *Sitones* and wire-worm. "There is scarcely a plant that has not one or more of these creatures attached." Mr. Willis has been good enough to send me several communications on the subject, and a supply of the worms, living and in spirit. Much of his information is interesting, as that the more decayed the root, the larger the number of worms; that even healthy plants harbour a few specimens; that the worms seem sometimes to enwrap the rootlets with their coiled body. He hears of other fields of clover in a similar condition apparently to those at Rothamsted. I have a quantity of detailed information, but to summarize it, there appears to be but little room for doubt that these small *Oligochæta* are one cause of the decay of the clover at Rothamsted, as they were of the many varieties of garden plants at Littledean.

The Enchytræidæ have not hitherto, so far as I can learn, been accused of causing serious injury to plants. Vejdovsky, in his "Monographie der Enchytræiden," says, "Die Enchytræiden bewohnen trockene und feuchte Erde, süsses und salziges Wasser, Sümpfe und morsches Holz." In what manner they directly injure the plant remains to be observed—probably by sucking the fine root-hairs. Under observation the pharynx is rapidly everted and withdrawn in the act of feeding. I have so far recognized two species. If, as seems not improbable, further corroboration should be forthcoming, we may find that we have to add to the list of enemies of the clover plant from which it so mysteriously suffers, these unsuspected Oligochætes. The discovery, though fraught with so little satisfaction to the already burdened agriculturist, can hardly fail to prove of interest to the zoological student of farm pests.

ALLEN HARKER.

Royal Agricultural College, Cirencester, April 10.

RAIN CLOUDS ON LAKE TITICACA.

THE cloud system here, 12,500 feet above sea-level, is so beautiful, and seems to throw so much light on the formation of one particular type of shower, that I venture to send diagrammatic sketches of two excellent specimens of cloud-building over rain.

I have never seen cumuloform clouds so perfectly developed as on this lake. Whether the height above the dust and haze of lower levels makes the blue sky darker than usual, or whether the temperature is such that the cumulus is composed of snow-flakes instead of water-drops, the contrast between the sky and cloud is much greater than usual.

The sketches were taken on a showery day, and the clouds were visible simultaneously in different directions. The type of shower is not unknown at home, but there much complication arises from the almost constant existence of cyclonic cloud systems.

Certain features are common to both pictures. Nearest the earth, appears a more or less conical-shaped space *r*,

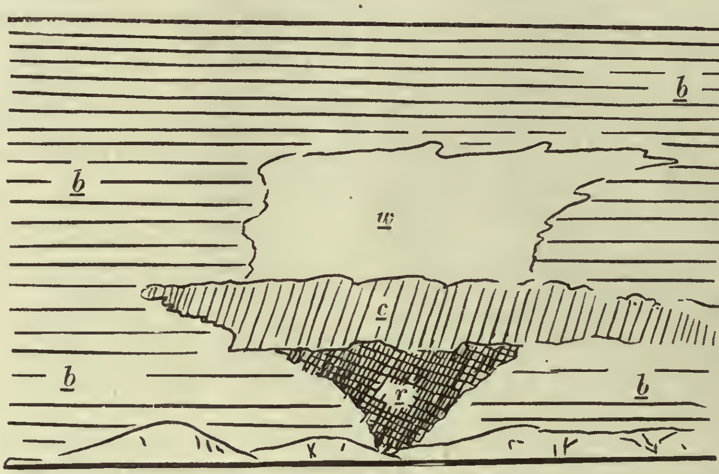


FIG. 1.—*b*, blue sky; *c*, flat-topped mass of dark cloud, rounded components; *r*, rain; *w*, white cloud, tending to flatten out and to cirrify.

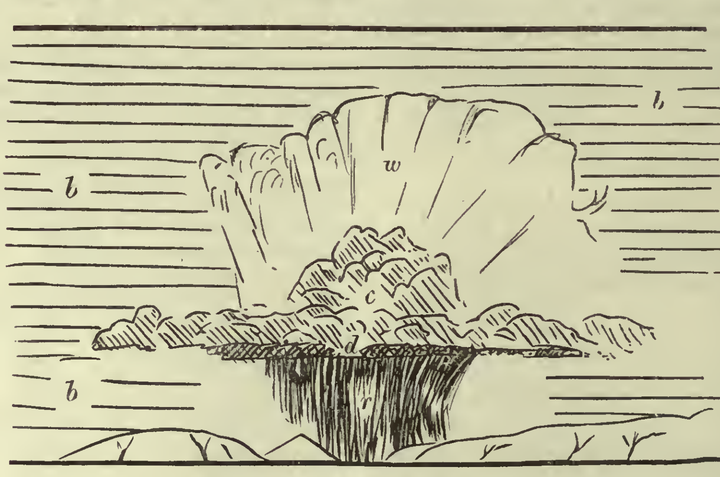


FIG. 2.—*b*, blue sky; *c*, dark cumuloform cloud, flat-topped at edges; *d*, dark belt; *r*, rain; *w*, white cloud, tending to flatten and to cirrify.

of uniform inky blackness, where rain is falling. Above, and stretching laterally some distance beyond the rain, is a belt of dark cloud, *c*, curiously flattened at the top; but the outlines are always *rounded*, and there is no trace of linear or hairy structure. In Fig. 2 a mountainous rocky cumulus rises above the flat dark mass *c*; and as the rain could be seen falling, I have indicated that appearance in the sketch.

In both, a white cloud, *w*, of remarkable shape and structure, rises above the dark mass *c*. Sometimes, as in Fig. 1, this cloud is nearly uniform in structure, but exhibits a tendency towards hairy structure at the edges. Other times, as in Fig. 2, the white cloud *w* shows traces of cumuloform structure of a very peculiar type. Instead of round, rocky lumps, the white cloud is composed of long, straight, fingery masses of cumulus, with a tendency to fibrous or hairy structure, and radiating slightly outwards from the base, like the head of a cauliflower. I have endeavoured to suggest this appearance by the straight lines, drawn through *w*, in Fig. 2; for the real structure defies delineation with pen or pencil.

In all cases, the top of *w* is more or less flat, and the whole diffuses outwards, sideways, or edgeways, rather than upwards. As the shower breaks up, *w* seems to be left as a middle-level layer of strato-cirrus.

The whole shower is surrounded by blue sky, there is no cirrus at a higher level; and while the low cloud *c* moves from north-east, the white cloud *w* may be coming either from north-east or more probably from north-west.

The puzzling nature of cloud perspective makes it very difficult to interpret the appearance of these clouds. There can be little doubt that the lower clouds, *c*, are the product of the condensation of rising columns of air; but while the somewhat cumuloform structure of *w* ought also to indicate an upward motion, the flat top, and outward diffusion, would suggest a more horizontal motion. I cannot therefore suggest any rational explanation of the building of these shower clouds; and the true nature of this phenomenon will only be discovered when the theodolite is used to determine whether *w* lies vertically or horizontally in the blue sky.

RALPH ABERCROMBY.

Lake Titicaca, February 28.

A FLAT FISH NURSERY.

PROF. EWART submitted the following report at a recent meeting of the Scotch Fishery Board:—

"I have to report that I recently discovered in the inshore waters what might best be described as a flat fish nursery. This nursery, which is about five miles in length, and from two to four miles in width, stretches along an exposed and only slightly indented shore, where the sea rises during spring tides from sixteen to twenty feet. The bottom of this area consists chiefly of fine sand, covered here and there with large patches of the common sea-mat (*Flustra*); the average depth is about four fathoms. When a small beam-trawl (with a net having meshes small enough to capture all the fish over two inches in length) was carried over the bottom parallel to and at a distance of about half a mile from the shore, large numbers of small flat fish were invariably secured. On one occasion as many as five hundred and sixty of these small fish were taken in less than an hour, and at all times the 'take' was large, and usually from 80 to 85 per cent. of the small flat fish were under two and a half inches in length. Some distance from the shore the takes were smaller, and on one occasion the trawl only secured twenty-three small fish, when used in about ten fathoms of water, some seven miles from shore. Along with the small flat fish, there were usually a few small round fish, a number of shrimps—sometimes over, sometimes considerably under one pint—numerous hermit and other crabs, and large quantities of *Flustra*. As it may be possible to materially increase the fish supply by affording protection to the young fish, I hope to be able ere long to report that other similar nurseries have been found, and also as to whether flat fish during their earlier stages of growth frequent the inshore in preference to the offshore waters.

"I have also to report that Mr. Scott (who in January last secured many thousands of plaice eggs floating in the open sea over a shoal of spawning plaice) has recently come across a large shoal of spawning haddocks which were apparently resting on the bottom at a depth of about 30 fathoms some fifteen miles off the coast of Banff. The surface waters over the shoal were crowded with haddock and cod eggs at nearly all stages of development. At a single sweep Mr. Scott with his tow-net secured nearly half a million eggs, while the trawlers were capturing hundreds of the spawning fish that were resting on or moving about near the bottom."

NOTES.

THE annual *conversazione* of the Royal Society will be held on Wednesday, May 8.

AT a meeting of the American Academy of Arts and Sciences on April 10, in Boston, the Rumford Medals were presented to Prof. Albert A. Michelson.

WE regret to have to record the death of Mr. R. Stirling Newall, F.R.S., at the age of seventy-seven. Mr. Newall's name was well known in connection with the invention and manufacture of wire rope and telegraphic cables. Just before his death he offered as a gift to the University of Cambridge the 25-inch refracting telescope which he had constructed some years ago.

THE Civil Service Estimates for the year ending March 31, 1890, show that a sum of £41,221 will be required for the maintenance of the Natural History Museum, South Kensington, for the present financial year. The corresponding sum in the Votes last year was £40,934. The principal increase is under the head of "Purchases and Acquisitions," for which the sum asked is £4700 instead of £3700. On the other hand, there is a decrease of £915 under the head of "Furniture and Fittings." The remaining heads do not show any material variation.

DR. LENDENFELD'S "Monograph of the Horny Sponges," which the Royal Society are about to publish, is now nearly through the press. It will consist of about 950 pages of text and over 50 plates.

WE have received the Report of the Mason Science College, Birmingham, for the year ended February 23, 1889. It is hardly creditable to Birmingham that the authorities of such an institution as this should still have to complain of a deficiency of income. Although the amount of the deficiency compares very favourably with those in former years, the Council feel that the economies they have been forced to adopt in order to decrease the difference between income and expenditure seriously impair the College work by hampering the Professors, especially those who have laboratories under their charge and require costly apparatus to illustrate their teaching.

PROF. H. G. SEELEY, to whom a sum was assigned from the Government Grant for a research on the Permian or Trias Reptilia, has been spending his Easter recess in St. Petersburg and Moscow. The officers and professors of the Academy, the University, and the School of Mines at St. Petersburg have shown him every attention, and his work in the museums appears likely to lead to important results.

MUCH excellent work has been done by the London Geological Field Class, which is carried on under the direction of Prof. H. G. Seeley. The Report relating to the excursions during the summer of 1888 shows that the work is conceived in a thoroughly scientific spirit, and that it cannot fail to exercise a most wholesome intellectual influence on all who take part it. This year, on account of Prof. Seeley's projected visit to South Africa in July, the class will begin its labours earlier than usual. The first excursion will take place on May 4. Many persons interested in geology ought to take advantage of this opportunity for the study of the country around London, and we are glad to learn that the secretaries have received the names of more subscribers than they have received at the same date in any previous year.

MR. DUTHIE, the Government Botanist for Northern India, who has been at work with Dr. King, of the Howrah Botanical Gardens, in classifying the plants collected by him when attached to the Black Mountain Expedition, has now been directed by the Government to make a special study of the grasses and fodders of Upper India.

THE *Times of India* says that the Sukkur Bridge, which has been constructed over the Indus, has now been opened. At Sukkur the river is very rapid, but the large island of Bukkur, standing about midway in the stream, was of great assistance in carrying out the plans. There are thus two bridges, one from Bukkur to the left bank, the other from Bukkur to the right bank. The latter consists of three spans, the longest of which is 278 feet; the former, known as the Sukkur Bridge, is in length between the abutments no less than 790 feet. Two cantilevers, 310 feet long, one from each side, were erected, and the intervening space of 200 feet was crossed by a girder. There was thus a space between the pillars of 820 feet, which is said to be the largest span of any rigid bridge in the world. The weight of the span is 3300 tons. The bridge was sent out in pieces from the works of Messrs. Westwood, of Poplar, and now, sixteen months after the arrival of the materials from England, it is practically complete.

A CORRESPONDENT writes to us about a "find" which, he thinks, may prove to be of some interest. At Hornsey, near Turnpike Lane, an excavation—about 18 or 20 feet wide, and about 20 feet deep—is being made in connection with a new pumping-station. In cutting into the clay, the men have come upon large fragments of a white substance, in the inside of which are what appear to be "the vertebræ of some animal." Our correspondent expresses a hope that some one competent to form an opinion about the matter will "take a run down to Turnpike Lane" (near the Great Northern station at Hornsey), and examine the objects which he believes to be fossils. After the present week, he says, there will probably be no opportunity of seeing the clay in the state in which it was when the objects were removed from it.

AT the meeting of the Scientific Committee of the Royal Horticultural Society, on April 23, Mr. W. T. Thiselton Dyer presented a note from Mr. Scott, the Director of the Meteorological Office, relating to the "useful" temperature as reckoned in "day degrees," and to the amount of sunshine since January 1 of the present year, as compared with recent years. The present season, it seems, has been much better than the last, except as regards the amount of sunshine, in which there is not much improvement.

SIR JAMES HECTOR has issued the Meteorological Report for New Zealand, containing observations for the years 1883 and 1884. Returns have been published since 1853, but since the year 1880 the number of stations has been greatly reduced, in favour of current weather reports ; the principal stations are now only four in number. With the view of enabling daily weather reports to be issued by the press throughout the colony, with the least possible expense, a series of twenty typical isobaric charts were prepared and are shown in the Report. Each represents a certain type of weather and bears a distinguishing number, which is telegraphed to the leading journals, so that when the number for the day is quoted, the diagram can be printed, and, although not absolutely correct, it is of great assistance in making known the general condition of the weather. The Report also contains some valuable returns from stations in the Fiji group of islands.

A NEW amine, methyl-ethylamine, $C_2H_5(CH_3)NH$, has been obtained by Drs. Skraup and Wiegmann, by the action of alcoholic potash upon morphine. Not only is the actual preparation of this hitherto unknown amine of importance in itself as completing a series of isomers of the formula C_3H_9N, but the fact of its derivation from morphine also throws considerable light upon the constitution of that alkaloid. It has been shown by several chemists that morphine, $C_{17}H_{19}NO_3$, is a derivative of phenanthrene, $C_{14}H_{10}$. As a methyl and an ethyl group have now been extracted in the form of an amine, it appears very likely that these groups are present in morphine, replacing two hydrogen atoms of phenanthrene and probably attached to nitrogen. If this be so, morphine may turn out to be the iso-nitrile of a substituted phenanthrene, and it remains now for future work to test the truth of this, and to determine the positions and functions of the oxygen atoms. In the latter connection, it was found in the course of this investigation that, in addition to the volatile amine, a second substance of phenol-like properties was also formed, but great difficulties were met with in its purification. In the actual experiments, morphine was heated for about five hours at 180° C. with ten times as much of a twenty per cent. solution of potash in alcohol. A volatile substance of amine-like odour was evolved, and was driven over by means of a current of coal gas into dilute sulphuric acid. The filtered acid solution was then supersaturated with soda and the purified amine distilled over in steam into a standard solution of hydrochloric acid. It was only found possible to eliminate from the morphine in this way about 50 per cent. of its nitrogen. The concentrated hydrochloric acid solution deposited crystals of a hydrochloride, and the solution also gave with platinum chloride crystals of a platino-chloride melting at 208°. Analysis of this latter salt showed that the amine present possessed the empirical formula C_3H_9N. There are four possible isomers of this formula, three of which, trimethylamine, propylamine, and isopropylamine, have been prepared ; and methyl ethylamine, which has hitherto been unknown. The hydrochloride yielded the base itself, by action of the strongest potash, in the form of a clear liquid of intense amine odour, unlike, however, that of trimethylamine. The properties of its salts were also found to exclude the possibility of its being propyl- or isopropylamine, so an attempt was made to prepare synthetically the only other possible isomer, methyl-ethylamine. This was successfully accomplished by heating methyl iodide with a mixture of 30 per cent. ethylamine solution and alcohol in a sealed tube at 100° for three hours. The product was distilled as far as possible in steam, the residue decomposed with potash, and the remainder of the volatile amines driven over in steam. The aqueous solution of the mixed distillate was then shaken with ethyl oxalate, and successive products were obtained, on concentration, of diethyl oxamide, acid ethylamine oxalate, and, lastly, the oxalate of the sought-for base, methyl-ethylamine. This salt, when recrystallized, melted at 154°, like the oxalate prepared from the amine derived from morphine ; and from it the hydrochloride, platinochloride, gold chloride, and free base were prepared, in every case the products being identical with those prepared from the base of morphine.

MESSRS. SMITH, ELDER, AND CO. have issued a third edition of Darwin's work on "Coral Reefs." To this edition Prof. Bonney contributes an appendix, giving an account of recent speculations—about which there was lately so much discussion in NATURE—as to the origin of coral reefs.

A CHEAP edition of Darwin's "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H.M.S. *Beagle* round the World," has been published by Mr. Murray. The portrait of Darwin which appeared in the NATURE series of "Scientific Worthies" is prefixed to this edition.

MESSRS. CHARLES GRIFFN AND CO. have published a sixth edition of "A Pocket-book of Electrical Rules and Tables for the use of Electricians and Engineers," by John Munro and Andrew Jamieson. The work has been thoroughly revised, and enlarged by about 120 pages and 60 new figures.

SOME valuable contributions towards a Flora of Caithness, by J. F. Grant and Arthur Bennett, have been reprinted from the *Scottish Naturalist*. The number of species and varieties that are admitted for the county of Caithness is over 600, a fair number, the authors think, considering the physical features of the county. Caithness has about 80 species that have not yet been found in Sutherland, and about the same number not yet found in the Orkneys.

THE Smithsonian Institution has issued six lithographs illustrative of the anatomy of *Astrangia Danae*. The plates were drawn by Mr. Sonrel, in 1849, under the direction of Prof. Agassiz, who intended to prepare a complete memoir on the subject. Mr. J. Walter Fewkes has written an explanation of the plates to make them available to students of marine invertebrates.

A NEW number of the *Internationales Archiv für Ethnographie* has been issued. It consists of Parts I. and II. of the second volume; and the contents, as in every preceding number of this excellent periodical, are full of interest for students of ethnography. There are three long articles—all in German. In the first, Dr. F. von Fuschan gives an instalment, carefully illustrated, of a paper on an amusement popular in Turkey, corresponding to the magic lantern. The second is an elaborate essay, also illustrated, by Dr. H. Schurtz, on knives made in various parts of Africa for the purpose of being thrown. In the third article, Mr. R. Parkinson, of New Britain, brings together many valuable ethnological facts relating to the inhabitants of the Gilbert Islands.

THE "Uses of Plants," by Prof. G. S. Boulger, which is about to be published by Messrs. Roper and Drowley, is a manual of economic botany, having special reference to vegetable products introduced during the last fifty years. It enumerates all vegetable substances in use in England as food, materia medica, oils, gums, rubbers, dyeing, tanning, and paper-making materials, fibres, timber, &c., both home-grown and imported; and there are short essays on the recent progress of vegetable technology in its various branches.

IN a Report lately received, Mr. W. Fawcett, Director of Public Gardens and Plantations, Jamaica, gives an interesting account of a visit of a few days to the Cayman Islands during May 1888. In an appendix he gives a list of the plants he collected, for the determination of which he expresses indebtedness to the authorities at Kew. "From this list," says Mr. Fawcett, "it will be seen that about 20 per cent. of the species are found more or less throughout the tropics. They are such as one might expect to find on any tropical island. It is interesting to note that one of the ferns (*Acrostichum aureum*) which is found growing to a height of 6 to 10 feet in swamps in Jamaica and throughout the tropics, was one of the first plants to establish itself on the Island of Krakatão, where the terrible volcanic disturbance completely destroyed every vestige of plant life. On its shore was also found the fruit of another plant occurring in the Cayman Islands, viz. the almond tree (*Terminalia Catappa*)."

AT a recent meeting of the Royal Asiatic Society of Japan, a paper was read by Dr. Seymour on the hygiene of Japanese houses, in which he disproves the common idea that dwelling-houses in that country are very unhealthy. A Japanese house, is, on the whole, suited to Japanese life. The extreme airiness of the structure prevents the charcoal fires doing the inhabitants any injury. Its chief defects can be easily remedied. The boarding of the floor can be made more close-fitting; ventilating panels should be used; the ceilings could with advantage be higher, and the drainage should be well looked after. Amongst foreigners there is distinctly more illness in brick and stone houses than in the wood or frame houses, on account of the damp remaining in the walls of the brick houses while it dries up almost immediately in the others. The remarkably small infant mortality amongst the Japanese shows that their houses are healthy and suited to their modes of life.

MR. F. A. HERON has been appointed an Assistant in the Zoological Department of the British Museum, not in the Geological Department, as stated (by a printer's error) in NATURE, vol. xxxix. p. 590.

THE additions to the Zoological Society's Gardens during the past week include two Macaque Monkeys (*Macacus cynomolgus* ♂ ♀), from India, presented by Mr. J. G. Mackie; two Caracals (*Felis caracal*) from Bechuanaland, presented by Captain Treville Cookson; a Ring-tailed Coati (*Nasua rufa*) from South America, presented by Mr. William Shiell; a Long-eared Owl (*Asio otus*), European, presented by Mr. Thomas B. Butler; three Orbicular Horned Lizards (*Phrynosoma orbiculare*) from Mexico, presented by Mr. T. H. Collins; a Rhesus Monkey (*Macacus rhesus* ♀), four Concave-casqued Hornbills (*Dichoceros bicornis* ♂ ♂ ♀ ♀) from India, a Crowned Hornbill (*Anthracoceros coronatus*) from Malabar, a Nepalese Hornbill (*Aceros nepalensis*) from Nepal, deposited; a Peacock Pheasant (*Polyplectron chinquis* ♂) from British Burmah, a Squacco Heron (*Ardea ralloides*) from Southern Europe, purchased; a Yellow-footed Rock Kangaroo (*Petrogale xanthopus* ♀), a Derbian Wallaby (*Halmaturus derbianus* ♀), born in the Menagerie.

OUR ASTRONOMICAL COLUMN.

THE APRIL METEORS.—Few of the April meteors appear to have been visible this year. They were watched for by Prof. Herschel at Croydon, Mr. Denning at Bristol, Mr. Backhouse at Hurworth (near Darlington), Mr. Monck at Dublin, and other observers. The shower of Lyrids was but weakly represented, and meteors generally were scarce. Several conspicuous ones were, however, recorded from the secondary streams of the April epoch. On April 20, at 10h. 16m., a meteor equal to Sirius was seen between Corvus and Virgo by Mr. Backhouse, and at the same time Prof. Herschel recorded a second-magnitude in Perseus. A comparison of the two paths shows the objects to have been identical, and the heights of the meteor at its beginning and end points, as computed by Prof. Herschel, were 50 and 46 miles respectively (over Derbyshire), which is much lower than usual. The radiant-point was at $301° + 34°$. Another brightish meteor was seen on April 21, at 10h. 16m., by Prof. Herschel and Mr. Denning, and its heights were from 76 miles above a point near Newport, Monmouthshire, to 60 miles near Brecon. The radiant was at $217° - 2°$, near μ Virginis. A fine meteor, quite equal to Venus, was observed at Bristol on April 27, at 8h. 51m., slowly descending in Hercules. Its path was from about $218° + 49\frac{1}{2}°$ to $249° + 32\frac{1}{2}°$. It left a trail of sparks as it fell, and its lustre fluctuated in a remarkable manner.

THE WHITE SPOT ON SATURN'S RING.—Prof. Holden reports that a careful examination of the ring of the planet with the great Lick equatorial on several evenings from March 2 to March 24 has resulted in the detection of no abnormal appearance in it. A kind of yellowish deformation or lump was indeed noticed close to the shadow on two or three occasions, but it proved to be due partly to bad definition, for it was only seen when the air was unsteady, and partly to contrast, for a similar appearance was produced in any part of the ring by the use of an occulting bar.

THE VARIABLE X CYGNI.—Mr. Yendall gives a new determination of the elements of this variable in *Gould's Astronomical Journal*, No. 191. Discovered by Mr. Chandler in 1886, it has proved a variable of very interesting character, and its light changes still require much study. The rise from minimum to maximum is generally sharp, but the interval varies much in length, the range being from 3·3 days to 8·7 days; the mean interval being 6·9 days. The curve is flat at minimum, and from these two circumstances Mr. Yendall has confined himself to the use of the maxima alone in the determination of his new elements. The decrease from maximum to minimum shows a remarkable halt, sometimes a positive rise, almost important enough to be considered a secondary maximum. Lastly, the magnitude touched at the extreme points of the curve varies from epoch to epoch, but with a general correspondence between the two phases, a bright maximum being accompanied by a bright minimum, and the contrary. A connection between the duration of the rise and the brightness at maximum has not yet been established. The elements given by Mr. Yendall are—

1886 October 10d. 6h. 11·8m. Camb. M.T. ± 52·3m. + 16d. 9h. 36m. 51s. ± 2·3s. E.

PHOTOGRAPHIC DETERMINATION OF THE BRIGHTNESS OF THE STARS.—No. 7 of vol. xviii. of the *Annals of the Harvard College Observatory* details the progress of the researches in stellar photography carried on at that institution by the assistance of the Bache fund, the particular direction in which the inquiry is being carried on being the determination of stellar magnitudes by means of photography. The present work is concerned with the determination of the brightness of the stars in three particular regions, each with special qualifications for the functions of standard stars; viz. 1000 close circumpolar stars, 420 stars in the Pleiades, and over 1100 equatorial stars. These three catalogues have been prepared with great care; the errors of the different photographic plates fully examined, and the relation of photometric to photographic magnitude investigated. The work therefore forms a most necessary and valuable introduction to a complete survey of the heavens on the same method. The instrument used was the Voigtländer photographic doublet, of 8 inches aperture and 44 inches focal length, so that the scale of the photographs was that of the atlas of the *Durchmusterung*, 2 centimetres to a degree. The images of the stars obtained on the plates were of different kinds, the clock sometimes being employed to drive the telescope when the stellar images were points or disks, sometimes the clock was stopped when trails were obtained, sometimes the clock was used but trails produced through the polar axis of the telescope not being parallel to that of the earth; indeed the adjustment of the polar axis was made in this way. The standard for measuring the stellar points was a photograph of the Hyades, the plate being exposed six times with exposures of 3 seconds, and 3^2, 3^3, to 3^6 seconds respectively. For measuring trails a plate was exposed to the polar region, and the aperture of the telescope varied to correspond to successive differences of a magnitude. The result of the careful and independent measurements of the plates showed that the measures of a skilled observer of the same star disk or trail did not vary on the average by so much as a tenth of a magnitude; so that if the errors due to the photographs themselves can be eliminated the photographic method of determining stellar magnitudes is at least as efficient as the best photometric methods. The comparison of the diurnal with the clock trails showed that the correction for declination to be applied to the former was only half 2·5 log cos δ, the value it should have had if the chemical action due to a certain amount of energy was independent of the time during which it acted.

The first of the three catalogues given in this work is that of the stars within 1° of the pole. Rectangular co-ordinates are given with the stars, instead of R.A. and declination. Of the 1009 stars included, 947 are within one degree radius from the pole, and nearly all are above the fifteenth magnitude. The catalogue of the Pleiades includes all of Wolf's stars between 3m. preceding, and 2m. following Alcyone, and 30′ north and 15′ south of that star with a few apparently overlooked by Wolf. The equatorial catalogue contains the stars within 2° of the equator. Ten different fields were photographed on each plate, one being exposed on the meridian, eight others right and left at intervals of 40m. hour angle, and the tenth on the polar region. A comparison of the results obtained brings out some interesting points. Tempel, at Marseilles, observing the Pleiades with a 4-inch telescope, reached fainter stars than Wolf at Paris with 12 inches aperture. The behaviour of photographic lenses of different apertures shows that to double the aperture is to command two additional magnitudes; to treble it, two and a half. A 24-inch aperture should, therefore, grasp stars below the seventeenth magnitude. A comparison of the photographic magnitudes with the Cordoba Catalogue, and the *Durchmusterung* gives distinct maxima for the residuals in the Milky Way, showing that the Catalogue magnitudes are too faint near the Galactic stream where stars are numerous.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *MAY* 5–11.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 5

Sun rises, 4h. 26m.; souths, 11h. 56m. 32·0s.; daily decrease of southing, 5·1s.; sets, 19h 27m.: right asc. on meridian, 2h. 50·7m.; decl. 16° 23′ N. Sidereal Time at Sunset, 10h. 22m.

Moon (at First Quarter on May 8, 7h.) rises, 7h. 57m.; souths, 16h. 17m.; sets, 0h 35m.*: right asc. on meridian, 7h. 11·7m.; decl. 22° 41′ N.

Planet.	Rises. h. m.		Souths. h. m.		Sets. h. m.		Right asc. and declination on meridian. h. m.		° ′
Mercury..	4 44	...	12 43	..	20 42	...	3 37·3	...	20 51 N.
Venus ...	3 44	...	11 24	..	19 4	...	2 17·8	...	17 59 N.
Mars ...	4 52	...	12 44	...	20 36	...	3 38·2	...	19 47 N.
Jupiter ...	23 46*	...	3 42	...	7 38	...	18 35·2	...	22 57 S.
Saturn ...	10 32	...	18 11	...	1 50*	...	9 6·6	...	17 47 N.
Uranus ...	16 46	...	22 15	...	3 44*	...	13 10·7	...	6 48 S.
Neptune..	5 18	..	13 4	...	20 50	...	3 58·3	...	18 52 N.

* Indicates that the rising is that of the preceding evening and the setting at of the following morning.

May.	h.	
5 ...	17 ...	Mercury in conjunction with and 1° 9′ north of Mars.
7 ...	22 ...	Saturn in conjunction with and 1° 28′ south of the Moon.

Saturn, May 5.—Outer major axis of outer ring = 41″·0: outer minor axis of outer ring = 11″·6: southern surface visible.

Variable Stars.

Star.	R.A. h. m.		Dec′. ° ′			h. m.	
U Cephei ...	... 0 52·5	...	81 17 N.	...	May 6,	1 52	*m*
					,, 11,	1 31	*m*
X Boötis ...	... 14 18·9	...	16 50 N.	...	,, 10,		*m*
δ Libræ ...	... 14 55·1	...	8 5 S.	...	,, 6,	23 51	*m*
W Herculis...	... 16 31·3	...	37 34 N.	...	,, 6,		*m*
U Ophiuchi...	... 17 10·9	...	1 20 N.	...	,, 6,	2 30	*m*
					,, 6,	22 38	*m*
U Aquilæ ...	... 19 23·4	...	7 16 S.	...	,, 11,	1 0	*M*
S Vulpeculæ	... 19 43·8	...	27 1 N.	...	,, 8,		*m*
η Aquilæ ...	... 19 46·8	...	0 43 N.	...	,, 9,	1 0	*M*
S Sagittæ ...	... 19 51·0	...	16 20 N.	...	,, 6,	22 0	*M*
S Aquilæ ...	... 20 6·5	...	15 18 N.	...	,, 10,		*m*
X Cygni ...	... 20 39·0	...	35 11 N.	...	,, 7,	2 0	*M*
T Vulpeculæ	... 20 46·8	...	27 50 N.	...	,, 11,	23 0	*m*
δ Cephei ...	... 22 25·1	...	57 51 N.	...	,, 8,	21 0	*m*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near ε Crateris	170° ...	10° S. ...	Very slow.
,, η Ophiuchi	255 ...	20 S. ...	Slow; long.
,, ζ Draconis	260 ...	64 N. ...	Slow.

GEOGRAPHICAL NOTES.

THE discovery is announced of a new mouth of the Zambesi, forty-five miles south of the Quaqua, on which Quillimane is situated. The name of the river is Chindé. As we know already of a Chindé River which joins two of the principal mouths of the Zambesi, the probability is, not that a new mouth has been discovered, but that an already known mouth has been more completely explored. The Chindé, it seems, has a channel some 500 yards wide, with three fathoms of water at the lowest, and is therefore expected to afford a clear waterway to the main Zambesi.

FOR the last few years Baron Nordenskiöld has been engaged on a work of great importance in the history of geography, and especially of cartography. He has been collecting from the archives of various European countries specimens of the earliest printed (as distinguished from manuscript) maps, and some of his finds are really original discoveries. These he intends to reproduce in a great atlas with accompanying text, in which, among other things, he will describe and discuss the various editions of Ptolemy; of these he has formed a unique collection. The work will appear both in a Swedish and an English edition.

THE country of Oklahoma, about which we have heard so much during the past fortnight, is in the very heart of what is known as the Indian Territory, which lies between Kansas on the north and Texas on the south. Although on the Survey maps of the United States it seems to be well watered, the actual results would show that the water is not well distributed. It is traversed by the Canadian and Cimarron rivers, and between them are found on the map a perfect network of streams. The area of Oklahoma is a little over 3000 square miles, equal to about one-twentieth of the total area of the Indian Territory; the number of Indians in the latter is about 80,000.

IN an article in the May number of the *Fortnightly Review*, by Mr. F. C. Selous, the well-known South African hunter and explorer, we find a useful account of Mashonaland, around which at present there is so much interest. No man knows the country so well as Mr. Selous, who during the past ten years has traversed it in all directions. Mashonaland lies to the north-east of the Matabele country, and is described as a land of perennial streams, where thirst is an unknown quantity. The high plateau, which is of very great extent, forms the watershed between the Zambesi to the north and east, and the Limpopo and the Sabi to the south; it is from 4000 to 4600 feet above sea-level. Nearly the whole of it is magnificently watered by a network of running streams, the springs supplying which well out from the highest portions of the downs, so that an enormous area of land could be put under irrigation. The whole year round a cool wind blows almost continuously from the south-east, a wind which in the winter months becomes so cold that it may well have its origin among the icebergs of the Antarctic seas. The country, Mr. Selous assures us from his own experience, is admirably adapted for European occupation and labour. The soil is rich and fertile, and from the facilities for irrigation enormous quantities of wheat could be grown. Although the highest and healthiest parts of the country are very open, still one is never out of sight of patches of trees. Besides the high plateau of Mashonaland, the whole of which is over 4000 feet above sea-level, extending along the watershed for a distance of over 200 miles from the Matabele country to the source of the Hanyane and Mazoe Rivers, with a breadth of from sixty to one hundred miles, there is a vast extent of country lying to the south, east, and north-east of the plateau, well-watered and fertile, having an altitude of from 3000 to 4000 feet. These plateaus are of much ethnological interest, as giving shelter to the very few remnants of the peaceful Mashonas that have escaped extermination at the hands of the bloodthirsty intruders, the Matabele.

Mr. Selous leaves England for the Cape to-morrow. It is possible that he may be compelled to lead a prospecting party up the Zambesi. Should this not be the case, he is likely to proceed northwards beyond the Zambesi to the Garenganze country, west of Lake Bangweolo, and thence make either for the source of the Lualaba, which he will endeavour to follow down until it broadens out into the Congo.

M. J. Taupin, Professor in the College of Interpreters at Saïgon, has completed an important exploration in the lower Laos country. Starting from Saïgon in October 1887, M. Taupin, after visiting the Siamese province of Siem-Reap, and photographing the numerous Khmer remains in that province, notably those of Angkor, crossed the forests of the lower Laos, to Ubon, where he resided several months. Among other things he has obtained a knowledge, at least summary, of the Laotian language and writing, the only graphic-alphabetic system, it is stated, on which we have no positive information. The language, M. Taupin states, is spoken by four million people. He has surveyed about 1000 kilometres of rivers and watercourses not found on any map, besides making many important corrections. He has made many notes on natural history, and experimented with the culture of European plants. The meteorology and anthropology of the country, moreover, received much attention at his hands.

At the next meeting of the Geographical Society, on May 13, the evening will be mainly occupied with a discussion of Mr. Stanley's letters, in which several well-known African authorities are likely to take part.

Captain Binger, a French explorer, has succeeded in filling up one of the blanks on the map of Africa. Starting from the banks of the Niger, he penetrated the country of Kong, amid many dangers and sufferings.

THE HENRY DRAPER MEMORIAL.[1]

The researches which constitute the Henry Draper Memorial have consisted for the last three years in the photographic study of the spectra of the stars. While this subject will continue to be the principal one under investigation, Mrs. Draper has decided to extend the field of work undertaken, so as to include the study of the other physical properties of the stars by photography. As will be seen from the detailed statement below, the first research undertaken is now rapidly approaching completion, the plans for the study of the southern stars have been matured, and this study will soon be begun; the detailed study of the spectra of the brighter stars is making progress, and a large piece of photometric work will soon be undertaken with a new telescope. The progress made in each investigation will now be described, as in previous Reports.

1. *Catalogue of Spectra of Bright Stars.*—The Bache telescope, which has an 8-inch photographic doublet as an objective, is used for this work. The photographs cover the entire sky north of $-25°$, with exposures of about five or ten minutes. About 28,000 spectra of 10,800 stars have been examined, including nearly all stars visible in Cambridge of the seventh magnitude or brighter. The Catalogue is now nearly ready for the printer, the final copy having been prepared as far as 14h. in right ascension.

Nearly the entire time of three or four computers has been devoted during the past year to this work. The intensity of about 15,000 of the spectra has been measured, completing this part of the research. Much time has been spent in checking and verifying the results. All the positions have been checked and brought forward to 1900 two or more times independently. All discordant measures have been re-examined, and a search has been made for possible error when bright stars are omitted or very faint ones inserted. Seven thousand two hundred notes have been made on the various stars in the Catalogue. Each note has an appropriate number which permits it to be entered in its proper place. Most of these notes relate to additional lines contained in these spectra besides those by which the type is determined. The position and intensity of these lines is estimated. A portion of them have been reduced to wave-lengths. The printing of the Catalogue might have been already begun but for the difficulty of deciding how the different types of spectra should be distinguished. The classification used for visual observations fails to indicate many differences obvious in the photographs. On the other hand, the photographic portions of spectra of Types II. and III. are nearly identical. The photographs also show many stars whose spectra are intermediate between those of the typical stars which have determined the usual classification. A system has, however, been adopted which permits all differences detected in the photographs to be described in the printed volume.

Thirteen spectra were found on these plates which could not be identified with stars. Three of these proved to be due to Mars, one to Vesta, three to Jupiter, four to Saturn, and two to Uranus. Accordingly all the exterior planets bright enough to be detected in this way appear on these plates.

The measures of the intensity of the spectra form a very important portion of this work. Since the same part of the spectrum is measured in each case, the true relative energy is determined. That is, the same result is obtained as if the measures of rays of the same wave-length were made by any other method, as photometrically by the eye, by the thermopile, or by the bolometer. The colour of the star will be indicated by the extent of the spectrum, which is also noted. For the first time, therefore, we shall have a photometric Catalogue in which the error due to the colour of the star is eliminated. A preliminary determination of the accordance of the results derived from different photographs of the same star shows that the average value of the residuals will be about 0·16, which is the same as the corresponding quantity for the Harvard Photometry. The number of stars is more than twice that contained in the latter Catalogue.

2. *Catalogue of Spectra of Faint Stars.*—In November 1888, the photographs required to cover the sky north of the equator were nearly finished. It was expected that in two months the observations would be completed. The telescope, which was the same as that used in the previous research, was, however, wanted for photographing the Solar Eclipse of January 1, 1889. It was accordingly sent to Willows, California, where it was mounted, and the greater portion of the remaining photographs were taken there. It was then sent to Peru, as will be described below. The few remaining photographs, including the repetition of those found on further examination to be unsatisfactory, will be taken in Peru.

3. *Detailed Study of the Spectra of the Brighter Stars.*—The 11-inch refractor with one, two, or four large prisms over its objective has been employed in this work throughout nearly every clear night, until stopped by the morning twilight; 686 photographs have been taken, most of them with an exposure of two hours. With our present photographic plates about 570 stars north of $-30°$ are bright enough to be photographed with one prism, 170 of them with two prisms, and 87 of them with four prisms. To obtain the best possible result some of the photographs must be repeated many times. The difficulty is increased by the invariably hazy appearance of the lines in some spectra, like that of α Aquilæ, which was at first attributed to poor definition of the photograph. It is expected that the work will be completed during the next year by original or repeated photographs of 228 stars with one prism, of 64 with two, and of 12 with four. In general, stars as bright as the

[1] "Third Annual Report of the Photographic Study of Stellar Spectra conducted at the Harvard College Observatory," Edward C. Pickering, Director. (Cambridge: John Wilson and Son, University Press, 1889.)

fourth magnitude can be satisfactorily photographed with one prism, the spectra obtained being about an inch long. Fainter stars, if of a bluish colour, give sufficiently distinct images, in some cases good results being obtained with stars of the seventh magnitude. For example, fourteen stars in the Pleiades are well photographed with this apparatus. With four prisms much longer spectra are obtained and many more lines are visible. But certain differences in the character of the spectra are better shown with the smaller dispersion. Numerous photographs have been taken of the variable stars *o* Ceti and β Lyræ. The changes in the spectrum of the latter star seem to be undoubted, those of *o* Ceti, if any, to be slight. Various peculiarities in the spectra of individual stars have been detected. One photograph of ζ Ursæ Majoris shows the K line distinctly double, and others show it single. Many photographs will be required to determine the law of its variation, if this is due to changes in the star itself. Bright lines were detected in the spectrum of ϕ Persei, putting it in a class in which only two or three other stars are known to fall. In the double star β Cygni the two components have spectra of different types, an important consideration in the theories regarding their formation. The brighter component is of the second type, the fainter of the first.

Ordinary photographic plates are not sensitive to rays of much greater wave-length than the F line, or 486. By staining the plates with various coal-tar products the range of sensitiveness may be greatly extended. With erythrosin the spectrum extends to the wave-length 590. The sodium line D is distinctly seen to be double in the photographs of α Boötis and α Aurigæ. Various experiments were also made with cyanin, but the plates were not sufficiently sensitive to give good results. The entire length of the spectrum with four prisms, including the portion obtained by erythrosin, is about six inches and a half.

A beginning has been made of the measures of the positions of the lines in the spectrum. A scale of fortieths of an inch has been ruled on glass, and the positions of the lines read off with the aid of a magnifying-glass. Twelve of the photographs of α Canis Majoris have been studied in this way. The spectrum of this star is traversed by the hydrogen lines, which are strong, and by other lines which are so faint that they are only visible when the dispersion is large and the definition good. The catalogue thus formed contains about 320 lines. The average deviation of the measures of the same line on different plates is about 0·05 of a millionth of a millimetre, or 0·05 cm. on the scale of Ångström's map. If the line occurs in the solar spectrum these measures will generally identify it. In other cases the exact position must be determined by a dividing engine. If a line can be distinctly seen, its wave-length can probably be thus determined with as great accuracy as that of the position of the solar lines on the map of Ångström. In the spectrum of α Boötis 140 lines are visible between the D and F lines.

The classification of this large number of spectra is a matter of no little difficulty. Slight differences exist in many stars, and certain stars appear to hold an intermediate position, so as to render a rigorous division into classes impossible. On the other hand, many stars appear to have identical spectra. The first step will be to arrange the stars in groups, and then compare the best defined spectra of different groups. A minute discussion and the measurement of wave-lengths will be necessary only in the investigation of a comparatively small number of spectra.

4. *Faint Stellar Spectra.*—The 28-inch reflecting telescope constructed by Dr. Draper was assigned to this work. During the first six months of the year a careful study was made of this problem, and the difficulties encountered bore evidence of the skill of Dr. Draper in obtaining good results with this telescope. The best method of using this instrument seemed to be a modification of the form first tried by Dr. Draper,—a slit spectroscope from which the slit had been removed. The rays from the mirror were rendered parallel by a concave lens which replaced the objective of the collimator. As this lens had the same focal distance as the objective of the observing telescope, it was not necessary that either should be achromatic. After long trials with this and other forms of apparatus, a spectrum was at length obtained showing good definition. As the results were not better than those described above, and the instrument, from its size, was slow in operation, the experiments have not been carried further.

5. *Catalogue of Spectra of Bright Southern Stars.*—The 8-inch Bache telescope remained in California until February 2, 1889, and was then sent to Peru to continue research No. 1 on the southern stars. The sky from $-25°$ to the south pole will be covered, and the resulting photographs sent to Cambridge and reduced, as in the case of the northern stars. The advantages of discussing all stars from the north to the south pole according to one system are very great, and are here secured for the first time in so extensive an investigation. If no unforeseen difficulty arises, the photographs will all be completed during the next two years.

6. *Catalogue of Spectra of Faint Southern Stars.*—Research No. 2 will also be extended to the south pole simultaneously with the observations required for No. 5. It is expected that these photographs also will be completed in two years.

The Bache telescope described above has proved an extremely convenient instrument for various purposes. Besides the spectroscopic researches already mentioned, several other investigations have been undertaken with it, some of which will be found in the Memoirs of the American Academy, vol. xi. p. 179, and the Harvard Observatory Annals, vol. xviii. Nos. iv., vi., and vii. Owing to its short focal length it possesses many advantages over photographic telescopes of the usual form. With exposures of an hour and a half more stars were photographed in the Pleiades than are given in the engraving accompanying the Annual Report of the Paris Observatory for 1886, although that work was based on photographs taken by the MM. Henry with exposures of three hours and a telescope having an aperture of 13 inches. Nearly twice as many stars were photographed in this region as were visible with the 15-inch telescope of the Harvard College Observatory. The short focus of the telescope also gives it especial advantages for photographing nebulæ. Twelve new nebulæ were thus discovered in a region where but eighteen were known before. Various other investigations, such as a determination of the law of atmospheric absorption, have been undertaken with the aid of this telescope. It has been so persistently used in spectroscopic work that the other researches have been neglected, especially those in which very long exposures were required. Its removal to Peru now cuts it off for some time from such use on the northern stars. Accordingly, Mrs. Draper has procured a similar lens, which is now in the hands of the firm of Alvan Clark and Sons for retouching and mounting. Several important researches will be undertaken with this instrument. Photography is now used in so many departments of astronomy that a general investigation of the photographic brightness of the stars seems desirable. A plan has been proposed by which a single plate will contain photographs of a number of regions one degree square, but in different portions of the sky. Thus a series of standard faint stars will be photographed, which can all be measured, and reduced to the same scale. One or more photographs of the vicinity of the north pole will be taken on each plate, and thus serve to correct the results obtained on different plates. It is proposed in this way to secure a series of standards of stellar magnitude at intervals of about five degrees. A third lens of similar form, having an aperture of four inches, will be attached to the telescope, with which photographs on a smaller scale, but five degrees square, will be taken simultaneously. These photographs will cover the entire sky, and it is proposed to measure the photographic brightness of all stars of the seventh magnitude, or brighter, which are represented on them. This investigation will have a special value in connection with the photometric measures of the spectra described above. It is hoped also to photograph the entire northern sky by means of the 8-inch telescope, with exposures of an hour. Each plate covers a region nearly ten degrees square, of which the images in the central five degrees square are satisfactorily in focus. One of the regions containing standard stars will appear in the centre of each plate. By such a series of plates the photographic brightness of any stars brighter than the fifteenth magnitude can be determined on a uniform scale. The faintest stars photographed will be nearly a magnitude fainter than the limit proposed by the Astrophotographic Congress, so that all plates included in that work can be reduced to a uniform system. The advantages of such plates for studies of the distribution of the stars and other similar investigations are obvious.

From the above description it appears that the field of work of the Henry Draper Memorial, as now extended, is almost boundless. The problems to be investigated relate to the fundamental laws regulating the formation of the stellar system. Questions of such importance should be discussed on a sufficiently large scale, or the results of the discussion will soon be superseded by a repetition of the work. The liberal provision made for the Henry Draper Memorial permits the investigations to be planned on a scale which is likely to avoid such undesirable duplication of work.

GRÜNWALD'S MATHEMATICAL SPECTRUM ANALYSIS.

THE following interesting criticism of Dr. Grünwald's recent work on the mathematical spectrum analysis of various of the elements, by Joseph S. Ames, of the Johns Hopkins University, appears in the February number of the *American Chemical Journal* :—

"Dr. Anton Grünwald, Professor of Mathematics in the Technical High School at Prague, has given his theory of spectrum analysis in the following papers :—(1) 'Ueber das Wasserspectrum, das Hydrogen-, und Oxygenspectrum,' *Astronomische Nachrichten*, No. 2797, 1887, and *Phil. Mag.*, xxiv. 354, 1887; (2) 'Math. Spectralanalyse des Magnesiums und der Kohle,' *Monatshefte für Chemie*, viii. 650, *Wiener Sitz. Berichte*, 2 Abth. xcvi., 1887; *Phil. Mag.*, xxv. 343, 1888 (abstract); and (3) 'Math. Spectralanalyse des Kadmiums,' *Monatshefte für Chemie*, ix. 956.

"His aim is to discover relations between the elements by tracing connections between their spectra, and thus to arrive at simpler, if not fundamental, 'elements.' He considers the lines in the spectra of two substances, say A and B. If he finds a group of lines in the spectrum of A, which, on multiplication with a simple numerical factor, give line for line a group in the spectrum of B, he assumes that A and B have a common component. This factor, which transforms the one group into the other, is, he says, the ratio of the volumes occupied by the common constituent in unit volume of the two substances. Thus, let *c* be common to A and B, and let it occupy the volume [*a*] in unit volume of A, and [*b*] in unit volume of B; then the factor which transforms that part of the spectrum of A due to *c* into that of B, also due to *c*, is [*b*]/[*a*]. It is not difficult to find relations between the spectra of different substances; and, accepting Dr. Grünwald's hypothesis as to the transforming factor, we can deduce formulas for the elements. For example, in the hydrogen spectrum there are two groups of lines, [*a*] and [*b*], which, when multiplied respectively by $\frac{19}{30}$ and $\frac{4}{5}$, give corresponding groups in the spectrum of water, and, since in water hydrogen occupies $\frac{2}{3}$ of the volume, we have the equations

$$[a] + [b] = 1$$
$$\tfrac{19}{30}[a] + \tfrac{4}{5}[b] = \tfrac{2}{3}$$
$$\therefore [a] = \tfrac{4}{5}, \quad [b] = \tfrac{1}{5}$$

which gives hydrogen the composition ba_4. For reasons which depend upon solar physics, Grünwald calls the substance *a* coronium, and *b* helium. Further, he says that all the lines in Hasselberg's secondary spectrum of hydrogen can be changed into water-line by multiplying by $\frac{1}{2}$; which shows, according to his theory, that the modified molecule H^1 occupies in H_2O half the volume it does in the free condition. He finds that oxygen has the composition $H^1 b_4 (b_4 c_5)_5$, where *c* is a new substance. In his last paper, however, Dr. Grünwald states that he has proved *c* to be nothing but *a* in a different state of compression.

"He adopts the spectrum of water, *i.e.* of the oxyhydrogen flame, as a standard, and is then able to give various criteria by means of which the primary elements *a* and *b* may be recognized. Among them are the following: If λ is the wave-length of any line produced by *a* as it exists in hydrogen, $\frac{19}{30}\lambda$, $\frac{3}{4}\lambda$, $\frac{56}{75}\lambda$ will each be the wave-lengths of any line of the water-spectrum, and if λ is the wave-length of any line produced by *b* as it exists in hydrogen, $\frac{4}{5}\lambda$ will be the wave-length of a line of the water-spectrum. Applying his criteria to magnesium, carbon, and cadmium, he finds that they are made up entirely of *a* and *b* in various states of compression. For instance, one group of lines in the cadmium spectrum is transformed into a group of *b* by the factor $\frac{2}{3}$, another group is identical with a group of *b*, and so on. But the group of lines of *shortest* wave-length is transformed into a group of *b* by the factor $\frac{7}{6}$; and cadmium falls in the seventh row of Mendelejeff's table. Similarly, the group of lines of shortest wave-length of zinc is transformed into a group of *b* by the factor $\frac{5}{4}$, and zinc is in the fifth row of the table. Dr. Grünwald finds in this a general law which he verifies in the cases of Al, Si, Fe, Cu, Zn, As, Sr, Ag, Cd, In, Sn, Sb, Te, Ba, Au, Hg, Tl, Pb, and Bi. He further connects the lines of greater wave-length with the substance *a*; and, as in all cases so far tried all the lines can be deduced from these two substances, he is led to believe that *all the so called elements are compounds of the primary elements a and b*.

"It is unfortunate that Dr. Grünwald has not published a complete list of the lines characteristic of *a* and *b*, for until this is done his theory cannot be accurately tested. There are two distinct questions to be answered: (1) Are there any numerical relations connecting the spectra of the elements? and if so, (2) what is the meaning of the fact? Cornu, Deslandres, and others have long since answered the first question for us, but whether Dr. Grünwald's answer to the second is correct or not depends upon the completeness with which the numerical relations hold for the *entire* spectra of the substances. It is here that Dr. Grünwald's work can be criticized.

"As noted above, the spectrum of the oxyhydrogen flame is used to test the existence of lines belonging to *a* and *b*. By far the most accurate and complete determination of this spectrum is that of Liveing and Dewar (Phil. Trans. 1888); but this does not always answer Dr. Grünwald's purposes. In the B. A. Report for 1886 there is a provisional list of lines of the water-spectrum, which he often uses, although the wave-lengths have since been corrected. Further, if other lines are necessary, they are found by halving the wave-lengths of the secondary spectrum of hydrogen. Many lines thus determined are actually present in the water-spectrum; but why are not *all* there? Dr. Grünwald says it is because the amplitude of vibrations of parts of the molecule can be so changed, owing to the presence of other substances, that the intensity may increase or diminish, or become too faint to be observed. To this argument there is absolutely no answer. In some cases, too, the average of two wave-lengths is used as a criterion of a wave-length of *b* which falls between them! And as a last resort, if the necessary wave-length cannot be found in the water-spectrum by any of these means, it is put down as 'new,' and is called an 'unobserved' line. As just shown, Dr. Grünwald easily explains why the strongest lines in the spectrum of an element, cadmium for example, when 'transformed' into water-lines, may be faint, and *vice versâ*. But how does he account for the fact that double lines are not transformed into double lines? This seems to me a fundamental objection. The concave-grating gives the only accurate method of determining the ultra-violet wave-lengths of the elements; and, as a consequence of not using it, most of the tables of wave-lengths so far published are not of much value. So Grünwald's error here may be great. And, besides, when we consider that in the water-spectrum as given by Liveing and Dewar, without the help of the secondary spectrum of hydrogen, there is on the average one line for every two Ångström units, it would be remarkable indeed if any law could not be verified. This is strikingly shown in the first group of the cadmium lines. Here 6742 and 6740 are two readings for the wave-lengths of the *same* line, as made by two observers; yet Grünwald finds a water-line for each of them!

"The fact that there are exact numerical relations connecting the spectra of different elements does not afford a proof of Grünwald's hypothesis; and until the above difficulties are removed the evidence is against it. But, even granting it, how do we know that *a* and *b* are not themselves compounds? In the second group of cadmium lines there are nineteen lines which can be transformed into *b* lines; *b* has many other lines; so at the most this only shows that cadmium and *b* have a common constituent unless, of course, the absence of the other cadmium lines is accounted for in Grünwald's own way of varying intensity.

"The lines of the spectrum of any substance, as carbon or iron, seem to fall into definite series or groups; and the wave-lengths of the lines in these groups can be expressed by formulas, as is well known. All that the fact of there being a connection between the spectra of different substances seems to show is, then, that there may be a formula common to many elements, as Kayser and Runge have recently found. And all that this means is that the molecules of those elements vibrate in general according to a similar law."

ON THE FORMATION OF MARINE BOILER INCRUSTATIONS.[1]

IN the older forms of marine boilers, sea water was almost universally employed; but with the introduction of high-pressure tubular boilers the amount of deposit was so serious, and the difficulty of removing it so great, that it became imperative to use distilled water. It is found, however, that the trouble has

[1] A Paper read at the thirtieth session of the Institution of Naval Architects, by Prof. Vivian B. Lewes, F.C.S., F.I.C., Royal Naval College, on April 11, 1889.

only been transferred from the steam boilers to the distilling apparatus, and that constant breakdowns of the latter necessitate the introduction of sea water into the boiler to eke out the supply of distilled water from the condensers.

The waters at present in use in marine boilers may be classified as—

(1) Sea water, (2) distilled water, (3) mixtures of sea water with distilled or fresh water.

In this paper the nature and causes of the deposits are studied in each of these cases.

Fresh water contains about twenty to fifty grains per gallon of dissolved solids, principally consisting of calcium carbonate, held in solution by carbonic acid present in the water, whilst sea water contains about 2300 grains per gallon, consisting principally of sodium chloride, together with magnesium salts and calcium sulphate. The wide difference in composition between fresh and sea water is also shown in the deposits formed by them. Analyses show that with fresh water the incrustation may be looked upon as consisting principally of calcium carbonate; that with a mixture of fresh and salt water the deposit consists of nearly equal parts of calcium carbonate and calcium sulphate; whilst the sea water gives practically calcium sulphate.

A deposit of calcium carbonate only, separates out as a soft powder, which remains suspended in the water for some time, and can fairly easily be removed from the boiler on cleaning; whilst calcium sulphate as formed in the boiler separates out in a crystalline form, and binds the deposit into a hard mass, so hard in fact that it requires the aid of a chisel and hammer to detach it from the plates and tubes, an operation which is extremely injurious, and tends to shorten the life of the boiler.

Calcium sulphate is much more soluble in a saline solution such as sea water than it is in fresh water, but its solubility rapidly decreases (1) on concentration of the saline solution, and (2) with increase of temperature and pressure.

Sea water having a density of 1·027 was evaporated, and analyses made at different densities with the following results:—

Saline Constituents per Cent.

Density ...	1·029	1·05	1·09	1·225
Sodic chloride	2·6521	4·4201	7·9563	23·8689
Calcic sulphate ...	0·1305	0·2175	0·3915	none
Calcic carbonate ...	0·0103	0·0171	none	none
Magnesic carbonate ...	0·0065	0·0032	none	none
Magnesic chloride ...	0·2320	0·3865	0·6960	2·0880
Magnesic sulphate ...	0·1890	0·3150	0·5670	1·7010

So that on concentrating sea water at ordinary atmospheric pressure, three distinct stages may be traced:—

(1) Deposition of basic magnesic carbonate;

(2) Deposition of calcic carbonate with remaining traces of the basic magnesic carbonate and hydrate; and, finally,

(3) Deposition of the calcic sulphate.

If the sea water be heated and concentrated above a density of 1·225, the salt commences to crystallize out.

These experiments show that if sea water be boiled merely under atmospheric conditions, it would be quite possible, by taking care that its density does not rise above a certain point (1·09) to prevent the deposition of the calcium sulphate; but any such regulation of density is rendered abortive by the fact that pressure and consequent raising of the boiling-point acts upon the calcium sulphate in solution in exactly the same way as concentration, as it is found that this substance is perfectly insoluble in either sea or fresh water at a temperature of 150° C. In the present high-pressure boilers, even if the sea water be mixed with a hundred times its volume of distilled water, so as to reduce its density very low, deposition of calcium sulphate still occurs.

Analyses of several specimens of deposits from boilers where sea water was used, showed that in all cases there were two distinct layers—(1) a hard crystalline deposit on the sides of the tubes, consisting of nearly pure calcium sulphate in the form of "anhydrite"; (2) a softer portion resembling alabaster in the interior, consisting of calcium sulphate, with about 6 per cent. of magnesic hydrate.

The presence of magnesic hydrate in boiler deposits is supposed to be due to the mutual decomposition of water and magnesic chloride, later experiments have shown, however, that when magnesic chloride and calcium carbonate mutually react upon each other, soluble calcium chloride and magnesium hydrate are formed; this explains why calcium carbonate is never found, except in very small quantities in marine boiler deposits.

When distilled water only is used, a slight coating is formed, practically consisting only of organic matter, whilst if at any time through a break-down in the distilling apparatus sea water is mixed with the distilled water, a thin and very hard scale of calcic sulphate is formed. An incrustation of this character gave on analysis:—

Calcic sulphate	90·84
Magnesic hydrate	0·75
Sodic chloride	1·41
Silica	0·85
Copper carbonate	1·11
Oxides of iron and alumina	0·24
Organic matter	2·96
Moisture	1·84
	100·00

This scale is of great interest from the presence in it of the carbonate of copper. It is well known that distilled water has a far greater solvent effect upon metals than a water containing salts in solution, and it is quite conceivable that the distilled water from the surface condensers attacks the brass and copper tubes and fittings, and deposits the copper on the tubes of the boiler, although in only small quantities; and it is interesting to note that the green spots due to the presence of the copper are all on the under side of the scale—that is, in contact with the metal of the boiler tubes, showing that in all probability it had been deposited, as suggested, from the water in the boiler, and in contact with the iron would set up local galvanic action and tend to produce pitting.

The importance of preventing boiler incrustation, and thereby saving the enormous waste of fuel and injury which it entails, has not been without influence on the minds of inventors, and almost every conceivable substance, from potato-parings to complex chemical reagents, have from time to time been patented for this purpose, but have failed more or less for marine boilers, because either they have had an injurious effect upon the metal of the plates, or else have produced an enormous bulk of loose deposit, which, although easily cleaned out if the various parts of the boiler were accessible, and if it were only being used intermittently, yet in a marine boiler continuously working, rapidly chokes the portions between the tubes.

For these reasons, no treatment of the sea water in the boilers themselves is practically possible, and with high-pressure tubular marine boilers the water must be either condenser water, made up to the required bulk with distilled water, as is at present done, or else the condenser water must be augmented by sea water specially prepared for the purpose in a separate apparatus before being supplied to the boilers.

If the engines of a vessel are in good condition, she will approximately require 1 ton of water per 1000 horse power per twenty-four hours, to make up the volume of the condenser water to the amount required for the boilers, so that, even supposing the engines not to be in good order, and considerable waste to take place, 10 tons per diem would be an outside allowance for even very large vessels. To obtain this amount of treated sea water the author proposes an arrangement, full details and diagram being given in the original paper.

The sea water, containing 40 pounds of soda crystals to the ton is heated up under pressure in a separate apparatus by passing through the solution superheated steam. Under these conditions the precipitated mixture of calcium and magnesium carbonates becomes very dense and settles very quickly. The water is then forced through filtering frames into the hot well of the boiler and is then ready for use. The whole process is effective and rapid, and simple arrangements are made for flushing out the apparatus, after each batch of water.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The courses of science lectures this term are as numerous as usual, but present few noteworthy features. Mr. Gardiner gives a general course of Botany, while Mr. Darwin is conducting the course of Elementary Biology (Plants), the lectures being given in the Archæological Museum Lecture Room. Prof. Macalister is lecturing on the History of Human

Anatomy, a subject on which a brief volume from his pen would be very acceptable. Prof. Foster's course is on the Physiology of the Senses this term.

Among the numerous courses of demonstrations in the Cavendish Laboratory we may note those of Mr. Wilberforce on Dynamo-Electric Machines (Alternating Current Generators and Transformers).

Two lectures will be given in the Literary Schools on June 4, and June 8 at 2.15 p.m., by Dr. Francis Warner, on the Study of Mental Action and the Classification of Pupils according to their Brain Power.

LONDON.—The following appointments of Examiners in various branches of Science in the University of London were made on Wednesday, April 24:—Prof. Hill and Dr. Larmor as Examiners in Mathematics and Natural Philosophy; Prof. FitzGerald and Mr. Glazebrook as Examiners in Experimental Philosophy; Dr. Pole and Sir John Stainer as Examiners in Music; Prof. Tilden as Examiner in Chemistry; *Prof. H. E. Armstrong, F.R.S., as Examiner in Chemistry; Prof. Bower and Prof. Ward as Examiners in Botany and Vegetable Physiology; Mr. Sedgwick as Examiner in Comparative Anatomy and Zoology; *Sydney J. Hickson as Examiner in Comparative Anatomy and Zoology; Prof. Boyd Dawkins as Examiner in Geology and Palæontology; *Prof. Charles Lapworth, F.R.S., as Examiner in Geology and Palæontology. The asterisks denote new appointments. The gentlemen to whose names no asterisks are prefixed held the same appointments last year.

SCIENTIFIC SERIALS.

American Journal of Science, April.—Contributions to meteorology, by Elias Loomis. In this paper, which was read before the National Academy of Sciences, November 14, 1888, the chief subjects discussed are the relations of rain areas to areas of high and low pressure. From these studies it appears generally that no great barometric depression with steep gradients ever occurs without considerable rain; that in great rain-storms the barometric pressure usually diminishes while the rainfall increases; that the greatest depression of the barometer generally occurs about twelve hours after the greatest rainfall; that a great rainfall is favourable to a rapid progress of the centre of least pressure. It also appears that in Great Britain the amount of rain with a falling barometer is twice that with a rising barometer; but this ratio diminishes rapidly eastwards, the precipitation in Central Europe being greater when the barometer is rising than when it is falling.—The sensitive flame as a means of research, by W. Le Conte Stevens. These experiments, which take as their starting-point Lord Rayleigh's memoir on "Diffraction of Sound" (Proceedings of the R. Institution, January 20, 1888), tend to show that the sensitive flame is not applicable for purposes of exact measurement, though it is much more nearly so than has been generally supposed. Without its aid it would have been impossible to establish the important analogies here shown to exist between light and sound.—The Denver Tertiary formation, by Whitman Cross. In this paper a succinct account is given of the newly determined Tertiary formation about the Denver district, Colorado, which had hitherto been assigned to the Laramie Cretaceous. Although of limited geographical extent, this formation possesses features of special importance in several respects. The vertebrate remains here occurring present some very remarkable associations, which appear to be in direct conflict with all past observations.—Events in North American Cretaceous history illustrated in the Arkansas-Texas division of the south-western region of the United States, by Robert T. Hill. Here are embodied the results of the author's investigation of the stratigraphic and palæontological conditions in the northern and eastern termination of the Texas Cretaceous, which are brought into relation with the corresponding formations in the Gulf and Western States.—The distribution of phosphorus in the Luddington Mine, Iron Mountain, Michigan, by David H. Browne. The results are here given of some 3000 analyses of ore from the Luddington Mine made during the last three years by the author while acting as chemist to the Lumberman Mining Company. Although no generalizations are attempted, these analyses tend to throw much light on one of the most difficult problems in the chemistry of iron ore—the distribution, throughout the vein, of Bessemer ore, and its relation to the formation of the deposit.—Papers were contributed by C. S. Hastings, on a general method for determining the secondary chromatic aberration for a double telescope objective, with a description of a telescope sensibly free from this defect; by G. Baur, on Palæohatteria, Credner, and the Proganosauria; and by O. C. Marsh, on some new American Dinosauria, with a comparison of the principal forms of the Dinosauria of Europe and America.

Bulletin de l'Académie Royale de Belgique, March.—On the discovery of some fossil remains of mammals anterior to the diluvium at Ixelles near Brussels, by Michael Mourlon. These deposits, brought to light in August 1888, were all found at a lower level than that of the rolled Quaternary gravels, and at some points were overlain by several beds of undisturbed shingle. They include remains of the cave bear, of *Elephas antiquus*, of *Bison priscus*, *Bos primigenius*, the hare, *Equus caballus*, and a smaller equine species here described under the name of *Equus intermedius*, altogether forty four individuals, representing five known and four not yet determined species, and presenting a general resemblance to the mammalian fauna of the English forest-bed.—On the physical properties of the free surface layer of a fluid, and on the contact layer of a fluid and a solid, by G. Van der Mensbrugghe. The experiments here described lead to results opposed to the capillary theories of Laplace and Poisson; they further show that the theory of Gauss is intimately associated with the surface tension of fluids, one leading inevitably to the other, and confirming the author's previous conclusion that the demonstrated existence of tension justifies the theory of Gauss.—Note on a theory of the secular variation of terrestrial magnetism deduced from experimental data, by Ch. Lagrange. Several arguments are advanced in support of the author's new hypothesis that the secular magnetism of the earth is due to a magnetic potential interior and not exterior to the surface of the globe. The solid globe itself is thus regarded as a magnet, or a solenoid—that is, as a magnetic body properly so called, or as a conductor traversed by circular currents.—A paper is contributed by P. De Heen on the determination of the theoretic formula expressing the variations of volume experienced by mercury with the changes of temperature.

Rendiconti del Reale Istituto Lombardo, March 28.—Influence of the digestive juices on the virus of tetanus, by Prof. G. Sormani. A series of experiments are described, which the author has carried out on rabbits, guinea-pigs, rats, and dogs, from which are drawn the following conclusions: (1) the flesh of animals dying of tetanus may be consumed with impunity; (2) the bacillus of tetanus swallowed by carnivorous and herbivorous animals passes through the system without causing death or any special disturbance; (3) the gastric juices of herbivorous animals neither kill, nor diminish the virulence of, the bacillus; (4) an animal may with impunity swallow a quantity of the virus ten thousand times more than would suffice to kill if introduced by hypodermic inoculation; (5) the facts here determined throw some doubt on the accepted theory that the effects of tetanus are due to the absorption of poisonous alkaloids derived from the bacillus.—G. Somigliana contributes a paper on differential parameters, explaining a process by which they may be formed, and demonstrating the invariability of those of the first order. Certain relations, either new or more general than those hitherto studied, are also established between the parameters of the first and second orders.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 4.—"The Ferment Action of Bacteria." By T. Lauder Brunton, M.D., F.R.S., and A. Macfadyen, M.D., B.Sc.

The chief objects of this research were, (A) to discover whether microbes act on the soil upon which they grow by means of a ferment; and (B) whether such a ferment can be isolated, and its action demonstrated on albuminoid gelatine and carbohydrates, apart from the microbes which produce it, in the same way that the ferments of the stomach and pancreas can be obtained apart from the cells by which they were originally secreted.

The microbes used were Koch's spirillum, Finkler's spirillum, a putrefactive micrococcus, scurf bacillus, and Welford milk bacillus (Klein).

The results of the inquiry were as follows:—

(1) The bacteria which liquefy gelatine do so by means of an enzyme.

(2) This enzyme can be isolated, and its peptonizing action demonstrated, apart from the microbes which produce it.

(3) The most active enzyme is that formed in meat broth.

(4) Acidity hinders, alkalinity favours, its action.

(5) The bacteria which form a peptonizing enzyme on proteid soil can also produce a diastatic enzyme on carbohydrate soil.

(6) The action of the diastatic enzyme can be demonstrated apart from the microbes which produce it.

(7) The diastatic enzyme has no effect on gelatine, and *vice versâ*.

(8) The microbes, for purposes of nutrition, can form a ferment adapted to the soil in which they grow.

(9) The putrefactive micrococcus gave negative results.

Linnean Society, April 18.—Mr. Carruthers, F.R.S., President, in the chair.—In view of the approaching anniversary meeting, the following were appointed auditors:—For the Council, Dr. John Anderson and Mr. Jenner Weir; for the Fellows, Mr. T. Christy and Mr. D. Morris.—The President called attention to a valuable donation of books on fishes, including the celebrated work of Bloch, recently presented to the Society's library by Mr. Francis Day, who, he regretted to say, was lying seriously ill at Cheltenham; upon which a cordial vote of sympathy and thanks was unanimously accorded.—Mr. J. R. Jackson, Curator of the Museum, Kew Gardens, exhibited specimens illustrating the mode of collecting at Ichang, China, the varnish obtained from *Rhus vermicifera*, so largely used by the Chinese and Japanese for lacquering. He also exhibited some Chinese candles made from varnish seed-oil.—On behalf of Mr. Henry Hutton, of Kimberley, some photographs were exhibited, showing the singular parasitic growth of *Cuscuta appendiculata* on *Nicotiana glauca*.—Dr. Cogswell exhibited specimens of vegetables belonging to four different families of plants, to illustrate the symmetrical development of rootlets.—Prof. Martin Duncan exhibited, under the microscope, and made remarks upon, the *sphæridia* of an Echinoderm.—Dr. Masters gave a summary of a paper on the comparative morphology and life-history of the Coniferæ, a review of the general morphology of the order based upon the comparative examination of living specimens in various stages of development. These observations, made in various public and private "pineta," supplemented by an examination of herbarium specimens, demonstrated the utility of gardens in aid of botanical research. The mode of germination, the polymorphic foliage, its isolation or "concrescence," its internal structure, the arrangements of the buds, the direction and movements of the shoots, were all discussed. In reference to the male and female flowers, the author described their true nature, tracing them from their simplest to their most complex or most highly differentiated condition; and showed that, so far as known, the histological structure and development were essentially the same throughout the order. Various special forms, such as the needles of *Pinus*, the phylloid shoots of *Sciadopitys*, and the seed-scales of *Abietineæ*, were described, and their significance pointed out. The phenomenon of enation with the correlative inversion of the fibro-vascular bundles in such outgrowths was considered in relation to the light it throws upon certain contested points in the morphology of the order; the chief teratological appearances noted in the order were detailed, and their significance discussed; the various modifications were shown to be purely hereditary or partly adaptive, and dependent on permanent or intermittent arrest, excess, or perversion of growth and development, and to various correlative changes; lastly, the polymorphic forms of the so-called genus *Retinospora*, suggested that in studying them we might be watching the development and fixation of new specific types.

Chemical Society, April 4.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—The rate of dissolution of metals in acids, by Mr. V. H. Veley. The dissolution of copper in a solution of potassium bichromate acidified with sulphuric acid was investigated as affording a case in which no gas was evolved as such. The copper was employed in the form of metallic spheres which by various mechanical devices were rolled about continuously and regularly in the acid liquid, and the products of the changes continuously removed from the immediate neighbourhood of the metal. The author finds (1) that if the temperature be varied between 21° and 41° in an arithmetical proportion the amount of chemical action varies in a geometrical proportion; (2) that if the amount of sulphuric acid be varied in an arithmetical proportion between the limits of 41·3 and 23·5 grammes per litre, the amount of change also varies in an arithmetical proportion; and (3) that the amount of change is at first considerably increased by increase of proportion of potassium bichromate, but the effect afterwards gradually diminishes to *nil*, at which point the bichromate can be considered to be so much inert material: the amounts used varied from 22·1 to 66·3 grammes per litre.—Note on the interaction of metals and acids, by Prof. H. E. Armstrong. When a metal forming an element in a voltaic couple is dissolved, the rate of dissolution is in accordance with Ohm's law, $C = E/R$: and this should apply also to the case in which a metal is dissolved without any precaution being taken to arrange it as an element of a couple, as the action is conditioned by the formation of, and takes place within, "local circuits." The changes attending the dissolution of metals may, therefore, in a certain sense be said to be purely electrical in the first instance; yet within recent years it has been argued by various chemists that the phenomena are only in part electrical and in part chemical—whatever this may mean. The author discussed the various phases of such changes, and criticized the conclusions arrived at by Spring and Aubel and others. Referring to Mr. Veley's experiments Prof. Armstrong expressed the opinion that the results were in no way commensurate with the labour expended in obtaining them: although by introducing bichromate polarization by hydrogen had been prevented, its use had introduced complications which made the analysis of the results impossible; in fact the information likely to be obtained from such experiments was not of the kind required in the present state of chemical science. Thus the proof obtained that a copper sphere dissolved uniformly in a mixture of sulphuric acid and bichromate was but a proof of the efficiency of the stirring apparatus: such would necessarily be the case, as the values of E and R remained almost unchanged throughout the experiment owing to the relatively small proportion of the agents used up. In the course of his reply Mr. Veley mentioned that he had had occasion to verify Dr. Russell's observation that silver is not dissolved by nitric acid free from nitrous acid, to which reference had been made, and stated that in experiments with copper and nitric acid he had observed that the action took place at first more slowly, and only attained a maximum rate when a certain small amount of nitrate was formed. Prof. Armstrong remarked that this was a really important observation, proving that the dissolution of copper in nitric acid was dependent on the presence of a third substance—perhaps cupric nitrate.—A zinc mineral from a blast furnace, by Mr. J. T. Cundall.

Zoological Society, April 29.—Sixtieth Anniversary Meeting.—Prof. Flower, C.B., F.R.S., President, in the chair.—In the Report of the Council on the proceedings of the Society during the year 1888, it was stated that the number of Fellows on January 1, 1889, was 3076, showing a decrease of twenty-eight as compared with the corresponding period in 1888. The total receipts for 1888 had amounted to £24,025 10*s.* 8*d.*, showing an increase of £922 15*s.* 2*d.*, as compared with the previous year. The receipts from admissions to the Gardens had risen from £12,138 to £13,284. The ordinary expenditure for 1888 had been £21,439 16*s.* 4*d.*, which was £2436 less than the corresponding amount for 1887. Besides this, an extraordinary expenditure of £700 had been incurred, which had brought up the total expenditure for the year to £22,139. The sum of £1000 had been employed in repayment of a temporary loan from the bankers, and a further sum of £1000 had been devoted to the diminution by that amount of the debt on the Society's freehold premises, which now stood at £7000. After deducting these payments from the income of 1888, and adding to it the balance of £1158, brought over from the previous year, a balance of £1043 was carried forward for the benefit of the present year. The usual scientific meetings had been held during the session of 1888, and a large number of valuable communications had been received upon every branch of zoology. These had been published in the annual volume of Proceedings for 1888, which contained 717 pages, illustrated by thirty-two plates. Besides this, Part 7 of the twelfth volume of the Society's quarto Transactions, illustrated by eight plates, had been issued. The volume of the "Zoological Record" for 1888, containing a summary of the work done by British and foreign zoologists in 1887, had been issued early in the present year. It had been edited by Mr. F. E. Beddard, the Prosector to the Society. An important event in connection with the Library during the past year had been the receipt from the executors of the late Madame Cornély, widow of the late M. J. M. Cornély, an old and valued corresponding member of the Society, of a valuable library of zoological books. The Cornély Library consisted of about 840 volumes, of which 256 were new to the Society's Library, and many of these were rare and difficult of acquisition. In the Gardens in Regent's Park, the work during the past year had been entirely confined to repairs and renewals, which, however, had kept the staff of workmen busily engaged. The visitors to the Gardens during the year 1888 had been altogether 608,402, the corresponding number in 1887 having been 562,898. The number of animals in the Society's collection on December 31 last was 2290, of which 666 were Mammals, 1280 Birds, and 314 Reptiles. Amongst the additions during the past year nine were specially commented upon as of remarkable interest, and in most cases representing species new to the Society's collection. About thirty-one species of Mammals, seventeen of Birds, and two of Reptiles had bred in the Society's Gardens during the summer of 1888.—The Report having been adopted, the meeting proceeded to elect the new members of Council and the officers for the ensuing year. The usual ballot having been taken, it was announced that Lieut.-Colonel the Lord Abinger, C.B., Mr. Henry A. Brassey, Mr. Henry E. Dresser, Lieut.-General Sir H. B. Lumsden, K.C.S.I., and the Lord Arthur Russell, had been elected into the Council in place of the retiring members; also that Mr. Walter Morrison, M.P., elected into the Council since the last anniversary, had been re-elected in place of the late Surgeon-General L. C. Stewart (deceased); and that Prof. Flower, C.B., F.R.S., had been re-elected President; Mr. Charles Drummond, Treasurer; and Mr. Philip Lutley Sclater, F.R.S., Secretary to the Society for the ensuing year.

PARIS.

Academy of Sciences, April 15.—M. Des Cloizeaux, President, in the chair.—Researches on the thionic series, by M. Berthelot. The author describes a new method recently discovered by him, by means of which he has succeeded in measuring the heat of formation of nearly all the terms in the thionic series, such as the dithionic, trithionic, tetrathionic, and pentathionic acids. The method consists in oxidizing the salts of the thionic acids, previously dissolved, by means of bromine dissolved either in water, or, better, in bromide of potassium. For acids formed by the union of the same element combined in multiple proportions of oxygen there is in most cases a certain proportion between the liberated heat and the combined oxygen, a law already indicated by Dulong.—Experiments on putrefaction and on the formation of manures, by M. J. Reiset. Detailed descriptions are given of the critical experiments briefly referred to by the author in his recent communication on this subject. He also deals with a serious objection that has been raised against his general conclusion regarding the liberation of nitrogen during the process of putrefaction.—Movement of cyclonic storms in the various regions of the globe, by M. H. Faye. A general survey is given of the salient features of these phenomena in the North Atlantic, the Bay of Bengal, the Arabian Sea, the Indian Ocean, the China Sea, and Japan waters—that is, in the regions where they have been most carefully studied. The author insists on the essential identity of all their main characteristics; everywhere the same rapid trajectory from the equator towards one or other of the poles; the same manner of gyration narrowing towards the base round about vertical axes; the same progressive expansion frequently developing phenomena of varied segmentation far from the equator; the same independence of local climatic conditions pointing to their common origin in the upper atmospheric regions, and showing that these violent disturbances do not belong exclusively to the science of meteorology, but are the grandest terrestrial manifestations of the mechanics of fluids, acting in conformity with the simple theory already, on several occasions, announced by the author.—Observations of Barnard's new comet, March 31, made at the Observatory of Algiers with the 0·50 m. telescope for the period April 4–10, by MM. Trépied, Rambaud, and Renaux.—On the specific heat of sea water at different degrees of dilution and concentration, by MM. Thoulet and Chevallier. The measurement of the specific heat has been executed according to M. Berthelot's method with water taken on the Fécamp coast, sometimes pure, sometimes with distilled water added, and sometimes concentrated by evaporation, the determination both of the densities and of the specific heats being made at the temperature of 17°·5 C. The calculations here worked out explain the enormous influence exercised by the sea in regulating the climates of the globe.—On the intensity of telephonic effects, by M. E. Mercadier. In continuation of his previous note (*Comptes rendus*, cviii. p. 737) the author here describes his further experiments with aluminium and copper diaphragms. The effects produced with these are found, under like conditions, to be far less intense than with iron diaphragms, the chief cause of the difference being the very slight specific magnetism of the former as compared with the latter. On the other hand, the *quality* of the effects produced by the aluminium and copper diaphragms is very remarkable, as they give the *timbre* of sounds and of articulate speech far better than iron.—Researches on some new metallic sulphides, by MM. Arm. Gautier and L. Hallopeau. In continuation of the already described studies (*Comptes rendus*, cvii. p. 911) on the action of carbon-di sulphide on the argillaceous earths, the authors have been led to examine its action on various metals at a red heat. The sulphides thus produced include those of iron, manganese, and the silicate of manganese described in this paper, and of nickel, chromium, lead, and aluminium, which are reserved for a future communication.—On the heat of combustion of some organic substances, by M. Ossipoff. The author has undertaken a series of experiments for the purpose of determining the heats of combustion of certain organic bodies not yet studied from the thermic standpoint. He has already completed the study of cinnamic, atropic, and terebic acids, all of which are described in the present paper.—Bacteriological researches on the disinfection of hospitals, dwellings, &c., by gaseous substances, and especially by sulphurous acid, by MM. H. Dubief and I. Bruhl. From these experiments it appears that gaseous sulphurous acid has a destructive effect on germs contained in the air, especially when saturated by the vapour of water; that it acts mainly on the germs of bacteria, and that when employed in the pure state for a prolonged period it may prove fatal to germs even in the dry state.

April 23.—M. Des Cloizeaux, President, in the chair.—On the theory of the capture of periodical comets, by M. F. Tisserand. The object of this paper is to supply a rigorous proof of the theory, based on Laplace's study of Lexell's comet, that the influence of Jupiter, acting on a comet with parabolical orbit, may under certain conditions transform its course to an elliptical orbit analogous to those of the group of periodical comets. Some of the formulas here worked out agree very well for two of Tempel's comets and for that of Vico; but full details are reserved for the next issue of the *Bulletin Astronomique*.—Memoir on the ravages caused to agriculture by the cockchafer and its larva, by M. J. Reiset. The results are described of the measures that have been taken in France for the destruction of this pest since the year 1866. A detailed account is appended of its remarkable biological transformations, and instances given of its surprising vitality, surviving complete immersion in water for over four days, and when buried to a depth of 0·40 metre in the earth remaining in a state of suspended animation for 150 days.—Observations of Barnard's new comet, March 31, made at the Observatory of Paris (equatorial of the east tower), on April 19, by Mdlle. D. Klumpke; at the same Observatory (equatorial of the west tower), on April 18–19, by M. G. Bigourdan; and at the Observatory of Bordeaux with the 38 cm. equatorial, on April 20, by M. G. Rayet. During these observations the comet generally presented the appearance of a slight nebula with a nucleus of the fourteenth magnitude.—On magnetic rotatory polarization, by M. Vaschy. It is shown that M. Potier's recent hypothesis (*Comptes rendus*, March 11, 1889) on the action of the ether on ponderable matter offers a remarkably simple explanation of this phenomenon. On the other hand, it lends no support to Ampère's theory regarding molecular currents.—On the initial mode of deformation of the ellipsoidal crust of the earth, by M. A. Romieux. M. Daubrée's well-known experiments serve as the basis of a theory of the original crumpling and folding of the terrestrial crust, which is here worked out with illustrations. M. Romieux considers that, although now far removed from that initial deformation, the globe still retains many traces of its effects as here described. Thus, the Pacific Ocean, a vast and very ancient equatorial basin, acting in opposition to a continental mass with its more recent depression of the Central Mediterranean, is supposed to have impelled by successive spasmodic pressures three or four zones of folding against the resisting mass of the North Pole.—On the combinations of ruthenium with nitric oxide, by M. A. Joly. Continuing his investigations on this subject (see *Comptes rendus*, cvii. p. 994), the author here adds a considerable number to the compounds of ruthenium with nitric oxide. They comprise a compound of nitric oxide with the trichloride, $RuCl_3(NO) + H_2O$, and with the sesquioxide, $Ru_2O_3(NO)_2 + 2H_2O$, both remarkably stable bodies, resisting the action of water, of bases and acids, and decomposing only at a temperature above 300° C. It is suggested that analogous nitrous combinations might be formed with rhodium, and with osmium. In a future communication M. Joly proposes to show that the substances described by Fritsche and Struve, under the names of osmanosmic or osmiamic acid and of osmiates, have a constitution similar to that of these compounds of ruthenium. — Researches on the richness of wheat in gluten, by MM. E. Gatellier and L. L'Hote. A series of experiments are described by which the same wheat (white Victoria) is made to yield increasing proportions of gluten. The increase largely depends on the rotation of crops and on the proportion of nitrogen to phosphoric acid contained in the manures.—Papers were contributed by M. J. Janssen and Colonel Gouraud on Mr. Edison's improved telephone, full details of which have already appeared in the English scientific journals. The proceedings concluded with the following phonographic message sent by the President to Mr. Edison : "M. le Président et les Membres de l'Académie des Sciences adressent leurs félicitations à M. Edison pour les nouveaux perfectionnements qu'il a apportés à son phonographe, et espèrent le voir bientôt à Paris, à l'occasion de l'Exposition Universelle."

BERLIN.

Physiological Society, April 12.—Prof. du Bois-Reymond, President, in the chair.—Prof. Fritsch gave a brief account of the results he has obtained from the examination of the electrical organ of Torpedo which he has been carrying on for several years. Both Wagner and Remak had correctly made out that each plate consists of two layers, one dorsal and one ventral ; that the nerves are attached to the plate from the under side, and are distributed in branches over it ; and that the under surface of the plate is dotted. Very little further information as to the structure of this organ has resulted from the many investigations subsequent to those of the above-named observers. Prof. Fritsch then explained and set aside the views of the best-known observers, and summed up his own conclusions as follows. The lowest or marginal layer is composed of a layer, which is here and there discontinuous, of globules, which refract light very strongly ; between these the terminal fibres of the nerves make their way into the plate. The pallisade-layer, which some previous observers had described, has an existence in the form of a number of extremely fine filaments, which stand at right angles to the plate, but inasmuch as they are so fine as to be scarcely visible, nothing can for certain be made out as to their nature. Passing further in a ventral direction, globular structures are found in the lower plate, seated upon fibres which branch dichotomously ; these may perhaps be bulbous nerve-endings. Large nuclei lie between the ventral and dorsal layers. The dorsal or muscular layer contains extremely fine granules, arranged in rows at right angles to the surface. The above results were obtained by the application of the modified treatment with nitric acid. A series of photographs and drawings was exhibited in explanation of that which was described, and several preparations were shown under the microscope.—Prof. Preyer spoke on reflexes in the embryo. His researches extended over many classes of animals. As representing Mammals, guinea-pigs were chiefly used ; and for reptiles, snakes ; while in addition the embryos of fishes, frogs, mollusks, and other lower animals were also employed. But of all animals birds are most suitable for embryological observations, inasmuch as, with due precautions, the development of one and the same individual can be followed for a considerable time. Birds' eggs can be incubated in a warm chamber, and by removing a portion of the shell and replacing it by an unbroken piece from another egg, it becomes possible to follow the daily development of the chick and to experiment upon it. As early as the ninetieth hour of incubation, spontaneous "impulsive" movements may be observed, taking place apparently without any external stimulus as a cause, and at a time when no muscles or nerves have as yet been developed. After the occurrence of these spontaneous movements, and at the earliest on the fifth day of incubation, movements are observed to result from the application of mechanical, chemical, and electrical stimuli. In order to observe these the eggs must be allowed to cool down until all spontaneous movements have ceased. From the tenth to the thirteenth day more complicated and reflex actions occur on the application of stimuli, as, for instance, movements of the eyelids, beak, and limbs ; and if the stimuli are strong, reflex respiratory movements. These reflexes make their appearance before any ganglia have become differentiated. Prof. Preyer considered himself justified in concluding from this that ganglia are not essential for the liberation of reflex actions. He intends, on some future occasion, to give a more detailed account of these experiments, and of the conclusions which may be drawn from them. In the discussion which ensued the conclusions of the speaker were contested from many sides.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Year Book of the Scientific and Learned Societies of Great Britain and Ireland. sixth annual issue (Griffin).—Subjects of Social Welfare : Sir Lyon Playfair (Cassell).—Biologie der Pflanzen, mit Einem Anhang : Die Historische Entwicklung der Botanik : Dr. J. Wiesner (Wien, Hölder).—The Theory of the Continuous Girder : M. A. Howe (New York).—A Vertebrate Fauna of the Outer Hebrides : J. A. Harvie-Brown and T. E. Buckley (Edinburgh, Douglas).—*Challenger* Report, vol. xxx. Zoology, Text and Plates (Eyre and Spottiswoode).—Animal Locomotion, 1872–85, Plates : E. Muybridge (Philadelphia).—The Metallurgy of Gold, 2nd edition : M. Eissler (Lockwood).—Himmel und Erde. Heft 8 (Berlin).—Journal of the Royal Agricultural Society of England, April (Murray).

CONTENTS.

THURSDAY, MAY 9, 1889.

THE ESTATE OF HER MAJESTY'S COMMISSIONERS OF 1851.

UNDER this heading the *Times* has announced that "a Sub-Committee of the Commissioners, amongst the members of which are Lord Thring, Sir Lyon Playfair, Mr. Childers, M.P., and Mr. Mundella, M.P., held a meeting on Saturday last to adopt a final report upon the disposal of this Estate which should be submitted for the approval of the Royal Commissioners themselves." The Commissioners have determined to let out a considerable part of their Estate to house builders, and the Sub-Committee had before them, on Saturday last, tenders for building leases. If the Commissioners accept these tenders, they will add some £10,000 a year to their income. This notion of sacrificing the Estate to builders of private houses has been known for some months; and, with the view of demonstrating against so short-sighted, not to say utterly immoral, a policy, a Memorial has been framed and circulated. We have received a copy of it, and, entirely acquiescing in its object, we print it *in extenso*. It runs as follows:—

To His Royal Highness the Prince of Wales, K.G., &c., &c., President of Her Majesty's Commissioners for the Exhibition of 1851.

The Memorial from the undersigned on behalf of ____________ [Here fill in name of Chamber of Commerce, Corporation, Guild or Educational Institution.

SHEWETH

(1) That in the year 1851 a large surplus profit accrued after the conclusion of the Exhibition of 1851.

(2) That this surplus profit was for the most part expended by Her Majesty's Commissioners for the Exhibition of 1851 in the purchase of a considerable Estate of land at Kensington, for the erection of public institutions, and generally to benefit the country's Arts, Sciences, Manufactures, and Commerce.

(3) That various public institutions, such as the South Kensington Museum, the Training School of Science and Art, the Natural History Museum, the Royal College of Music, the Royal Albert Hall, and the Imperial Institute, have been or are in course of being built upon this Estate.

(4) That fine open spaces intervene between the various institutions, to provide for further extensions of them, and give them proper light and air.

(5) That Sir Lyon Playfair, M.P., as Secretary to Her Majesty's Commissioners, recently stated in the House of Commons that a large portion of these fine open spaces between the public institutions already named was to be leased for the erection of private houses and mansions.

(6) That, in the opinion of Your Royal Highness's Memorialists, this crowding upon the public institutions of private houses and mansions is adverse to the interests of Arts, Sciences, Manufactures, and Commerce, and foreign to the intentions of Her Majesty's Commissioners, publicly announced, when they purchased the land, and also subsequently.

(7) That, in the opinion of Your Royal Highness's Memorialists, this crowding upon the public institutions to benefit Arts, Sciences, Manufactures, and Commerce, of private houses and mansions is in conflict with the last public announcement in respect of the future of the Estate which H.R.H. the late Prince Consort made within six months of his lamented death.

Your Memorialists, therefore, respectfully pray that Your Royal Highness, as President of Her Majesty's Commissioners, will prevent the public institutions on the Estate of Her Majesty's Commissioners from being crowded upon by private houses and mansions, and will induce Her Majesty's Commissioners to preserve intact those unalloted portions of their Estate in order that they may be placed to the great public uses for which the Estate was destined by Her Majesty's Commissioners and their President, Your Royal Highness's illustrious father, the lamented Prince Consort.

The *Times*, commenting upon the effect of the Commissioners' scheme for filling up their Estate with private houses, says that "the irregular blocks of variegated private houses" will more or less overwhelm and hedge in "such National Institutions for Science and Art as the Estate may ultimately contain."

From time to time the Commissioners' various proposals for dealing with their Estate have been publicly criticized, with the useful result that such of the proposals as were in the nature of distinct departures from the original intentions set forth at the time the Estate passed into their keeping, have been modified or dropped.

Twelve years or so ago, some representatives of the original subscribers, whose aid in 1851 virtually placed a large portion of the surplus funds at the disposal of the Commissioners, urged that unallotted portions of the Estate should be sold to meet expenses in founding provincial galleries or museums for science and art. For good reasons, the Commissioners did not give way to these plausible representations. They said at that time that, under the guidance of the Prince Consort, "we purchased the estate to provide an *extensive site for the development of great institutions for the promotion of industrial art and science amongst the manufacturing population*." At this very time, and, as was stated in NATURE of May 2, p. 3, the Commissioners proposed certain conditions to the Government, under which they (the Commissioners) would raise £100,000 as a contribution towards erecting a Museum of Scientific Instruments, a Science Library, and Laboratories of Scientific Research and Instruction. This proposal, which was not entertained however by the Government of the day, contained provisions for keeping the main parts of the Estate free for the development of national institutions. The reasons for keeping the main portions of the Estate at liberty in this way have since remained every whit as strong as they were then. Indeed they are stronger than ever, in the face of Government action now being taken in respect of the "National Science Museum." But a malign influence supervened. It was but a week before Christmas last year, when Mr. G. Samuelson asked a question in the House of Commons, that Sir Lyon Playfair stated that Her Majesty's Commissioners for the Exhibition of 1851 were arranging to dispose of considerable plots of land on their Estate to house builders, in order that the Commissioners might increase their income by obtaining ground-rents from private houses, and that the Commissioners did not intend to publish their reasons for this. Is Sir Lyon Playfair's assurance in thus apparently setting public opinion at defiance to be ascribed to a sense of relief from further responsibility which he may have derived from his resignation of the secretaryship to the Commissioners?

There is no ambiguity in his statement as to the choking up of the Kensington Estate with private houses and mansions. The sites to be occupied by private houses are bounded on the north by the Albert Hall and the adjoining semicircular arcades or quadrants, on the east and west by portions of the galleries containing the Museum of Science and the India Museum, and on the south by the Imperial Institute. They form the gardens and terraces so well known to the public who flocked to the evening *al fresco* entertainments which were given in connection with the series of International Exhibitions recently held at South Kensington. The various public announcements issued by Her Majesty's Commissioners during the last thirty-five years conclusively show that this land was acquired for more useful and comprehensive purposes than those of speculative house builders.

Let us briefly refer to those announcements. On the close of the Exhibition of 1851, H.M. Commissioners found themselves the possessors of some £200,000. They were impressed with the fact that many public institutions founded to promote science and art had been "subject to the disadvantages of being placed in such a situation from the crowding of surrounding houses that they were without light or air, and had no convenient access." They therefore determined to purchase a large estate of unoccupied land, and in 1852 became the landlords of what has since been commonly known as the South Kensington Estate. For the ultimate use of this large property they proposed to trust to the "voluntary efforts of individuals, corporations, and authorities, to carry out the promotion of the different interests with which they are themselves connected." In their Report for 1856, the Commissioners, alluding to "the question of the site that has been purchased by us," show that, during the intervening years, "the great natural capabilities of the site have been properly developed by means of the construction of important lines of communication and other improvements; and that we are still occupied in taking the remaining steps requisite for perfecting the estate, and rendering it in all respects fit for the great national objects to which it is to be applied." Very shortly afterwards a large area of the Estate was leased to the Royal Horticultural Society. This was laid out as an ornamental garden surrounded by arcades and galleries. The late Prince Consort opened this garden in 1861. His Royal Highness made a speech on the occasion, in the course of which he said, "We may hope that at no distant day this garden will form the inner court of a vast quadrangle of Public Buildings rendered easily accessible by the broad roads which will surround them, Buildings where Science and Art may find space for development, with that light and air which are well-nigh banished from this overgrown metropolis." This was but six months before the death of the Prince. For some years the Prince Consort's superior policy in dealing with the Estate was respected and followed by Her Majesty's Commissioners. The Natural History Museum arose on the land at the south of the Horticultural Gardens. Galleries were built above and at the side of the long eastern and western arcades of the gardens; other galleries were erected between these gardens and the Natural History Museum. The Government secured a tenure of all these galleries as a temporary home in which the Government has placed the National Science Museum, the Collections of Historic Machinery, the India Museum, and the Collections of Modern Industrial Art. On the far north of the Estate was built the Royal Albert Hall: then followed the Royal College of Music. Later still sprang up the Technological Schools of the City and Guilds of London Institute. But with all this steady realization of the Prince Consort's far-seeing policy the Commissioners were not satisfied. Pleading necessity to find money for defraying the expenses of certain not over-wise experiments undertaken by them, they began to let land on the margins of their Estate for the erection of private dwellings. And the more prominent result of this is the beetling mass of mansions opposite Hyde Park, overshadowing the Albert Hall on one side, and frowning ominously upon the "inner court of the vast quadrangle" of the Estate. Then came the movement for an Imperial Institute. A great slice out of the "inner court" was allocated for this mysterious Institute, which is rapidly asserting its architectural entity. At this point in the development of the Estate, the Commissioners, it would seem, succumbed to the hopeless temptation of washing their hands of further trouble. And, as we have already stated, their present intention is to block up the remaining portion of the "inner court" with private houses and mansions, and thus disencumber themselves of any responsibility for institutions for science and art.

Now, an explanation, which has been offered, of this *volte face* on the part of the Commissioners is this. The subscriptions for the Imperial Institute are insufficient for its endowment. It must be remembered that the Imperial Institute is the outcome of the "Jubilee" loyalty. The possible utility of this Institute has been debated without success. To lay the foundation-stone, and to pay for a staff of subscription-touters and what not, during two years, have exhausted some £25,000 of its capital, which does not reach £300,000. The ingenuity of Lord Thring and Sir Lyon Playfair has, it is said, been accordingly taxed. Their united wits are credited with having proposed the sale to private house builders of the unallotted land as well as of portions of land already occupied by galleries containing the Science Museum and India Museum. The money thus realized, or most of it, is to go into the coffers of the Imperial Institute. Such are the statements made. If they are wrong, they should be contradicted.

Another minor incident which further exemplifies the Commissioners' attitude is the projected removal of the monument raised twenty-five years ago on their estate to commemorate the Exhibition of 1851. This monument is surmounted by a statue of H.R.H. the late Prince Consort. This too is to be swept away to make room for private houses.

WARREN DE LA RUE.

A PROMINENT and representative figure has just disappeared from scientific circles, whose absence will be deeply felt by the many eminent men with whom, for a long time, he had been associated. In the

Councils of our great Societies he was a man invaluable for his intelligence, for his persevering energy, for his promptness of resource, and for a generosity, princely, but discriminating. These words will at once suggest the regretted decease of Warren de la Rue. At the age of seventy-four, he can hardly be said to have died full of years; but assuredly Warren de la Rue died full of honours. He was almost, but happily not quite, the last of a generation or two, of men who, possessing ample pecuniary means in middle or early life, devoted the means and the life to the search for truth in Nature, each in his own line. The two Herschels, Wollaston, Babbage, Gassiot, Spottiswoode, and De la Rue are gone, and but few like to them still survive, linking us with the past. "The old order changeth;" and now the endowed and professional student of Nature is fast displacing the amateur. Nor need we altogether deplore it; for, after all, the Professor and the amateur belong to the same race of Englishmen; they have the same love of the quest for truth ardent within them; and in the case of the Professor there is now superadded the spur that comes from a sense of duty.

Warren de la Rue was born in 1815, and was the son of Mr. Thomas de la Rue, the founder of that eminent firm of manufacturing stationers in Bunhill Row who have rendered well-known services to social life by the production of numerous articles, unsurpassed in excellence in their particular craft. He first became known to the world at large by his newly-invented machine for the manufacture of envelopes, which was placed in the Great Exhibition of 1851, and formed one of the chief objects of attraction there. Not far from it lay a small photograph of the moon, taken by Bond with the Harvard refractor of 15 inches. It was comparatively, and from the circumstances of the times necessarily, but a poor performance, yet it held out the promise of future possibilities, and it certainly fired the hopes of De la Rue. It was to him what the itinerant telescope in the streets of Bath became to the elder Herschel, viz. the determining point of a future and illustrious career. Accordingly, we soon find him engaged in the construction of, what in the sequel has become, his historic reflecting telescope, having an aperture of 13 inches and a focal length of 10 feet. The mirror was figured and polished by his own hands, and the equatorial mounting of the telescope was completed in his manufactory at Bunhill Row, from his own designs. Here again our thoughts revert to the elder Herschel; but that great astronomer never approached the perfection either of the De la Rue mirror, or of the mechanism by which it was mounted and by which it was moved. It is, however, only just to say that much of this notable improvement was the natural outcome of the lapse of time and of the progress that had been made in the working of metal. The instrument was mounted in the suburbs of London, at Canonbury, in a small garden surrounded by houses. It was hither, when the day's work was done at Bunhill Row, that De la Rue retired at night; and here, by patiently waiting for a clear and serene atmosphere, an event of rare occurrence, and then only during the small hours of the morning, he finally succeeded in taking telescopic pictures of the planets Jupiter and Saturn, which it may not be too much to say remain still the equals of any subsequent delineations of the same planets. Of the Saturn picture, John Herschel was heard to say that he could die content if he could but once see the planet itself as beautifully defined. This great success at once placed him among the chief amateur practical astronomers of the day.

It was about this time that he associated himself with Owen, Quekett, Bowerbank, and others, in the formation of the Microscopical Society; and such were the keenness and exactness of his eyes and hand, that he soon became a chief referee for the performance of the wonderful microscopic objectives which then for the first time were produced by the skill of Powell and Andrew Ross.

His first essays in lunar photography were not so successful as he had anticipated: the collodion plates were deficient in rapidity, and his telescope, not being as yet provided with a clock movement, he was unable to keep the moon motionless in the field, even for the short exposure requisite to secure a photographic image. All this, however, was soon rectified. For, about the year 1857, he removed his residence and his telescope from Canonbury to Cranford, a village distant from London by some twelve miles west. There he provided his instrument with an admirable driving-clock, and applied what leisure he could get, sedulously to celestial photography; and there he secured the earliest substantial results of a method, which, at present, bids fair to revolutionize the processes of the most exact and refined astronomy. The photographs of the moon which he now obtained still remain works of art, which even the most skilful of recent astronomers find it difficult to emulate with success. He also made many attempts to photograph the solar disk; but owing to mechanical difficulties, connected with the necessarily infinitesimal duration of the exposure of the plates, his success was not great. He had hoped that, by treating the photographs stereoscopically, he might decide the true nature of sun-spots in respect of their being depressions or the reverse; but, although the evidence seemed greatly in favour of depression, the question can hardly be considered as photographically settled. His efforts in this direction ended in the construction of a small telescope for the Royal Society, with an object-glass of 3½ inches aperture properly corrected; and, with this photo-heliograph, numberless pictures of the sun were successfully taken at the Kew Observatory. This instrument has proved the parent of many others established in various parts of the world, so that at present scarcely a day passes without a record of the condition of the sun's disk. The arrangements for these observations of sun-spots are now constituted under the advice of the Solar Committee at South Kensington, and in due time no doubt important facts will be brought to light. All this is traceable to the little inconspicuous photograph deposited not far from the envelope machine in 1851; and in this way De la Rue became, and will ever be remembered as, the Father of Lunar and Solar Photography.

In 1860, De la Rue took this photo-heliograph with him on board the *Himalaya*, in connection with the memorable expedition to the Spanish Pyrenees, for the purpose of observing the total eclipse of the sun. He posted himself, with his whole battery of implements, at Riva Bellosa, in the valley of the Ebro, not far from Vittoria. He was successful in obtaining several photographs of the eclipse during its totality, which gave the promise of settling, once for all, the hitherto much-mooted question as to whether the red prominences belonged to the sun, or were attributable to a different origin. On his return home he devised a micrometer for the due measurement of these remarkable phenomena, and in conjunction with other photographs taken by Padre Secchi, at a station some 250 miles distant from Riva Bellosa, he succeeded in allocating these singular fiery prominences beyond question, in the gaseous envelope which surrounds the sun. The results of his researches were embodied in the Bakerian Lecture delivered before the Royal Society in 1862. Perhaps it is not too much to say that these efforts laid the foundation of that wonderful structure of solar physics which is daily enlarging our knowledge of the true nature of the sidereal universe.

In 1873 the Observatory at Cranford was dismantled, on the occasion of De la Rue's removal from his comparative seclusion there to his residence in London. The reflector, with all its numerous and valuable accessories, was presented to the University of Oxford, and by this noble gift it was enabled at length to establish an efficient Astronomical Observatory at a place of learning where Halley and Bradley had flourished and taught nearly two centuries before. The instrument was erected in completeness at De la Rue's sole expense, and for several years he defrayed the cost of the additional assistant necessary for its utilization.

Oxford has at no time been backward in acknowledging with gratitude all efficient services rendered in behalf of the studies of the place. Accordingly, on De la Rue was conferred the rare honour of the full degree of M.A., by which he became a member of Convocation, while New College also incorporated him among her Society of Wykehamists, and made him a member of their common room.

We have occasion to know that it was a source of gratification to De la Rue to feel assured that his generous gift was utilized to the full by his old friend the present Professor of Astronomy, and specially in the direction which himself had inaugurated. Moreover, when a few months ago he saw the marvellous results produced by Mr. Roberts in his photographic pictures of nebulæ, secured by a four hours' exposure, he gave directions for the additional mechanism requisite for the production, as he hoped and believed, of similar pictures by his own now ancient instrument. Such is the solidity of the original mounting, that at this moment it is finally placed on a par, in respect of accurate movement, with any known instrument; but he did not live long enough to watch the progress of the experiment. Nor does this end the catalogue of his gifts to the University. When he heard of the projected scheme inaugurated by Admiral Mouchez, the Director of the Paris Observatory, for completing a photographic chart of the entire sidereal heavens, he placed a considerable sum of money in the hands of the Vice-Chancellor in order to defray the cost of the large photographic telescope necessary for taking a part in this great enterprise. The University of Oxford is not an ephemeral institution, and De la Rue's acts of generosity will remain inscribed upon her annals.

While he was thus watching with intense interest the uses made at Oxford of the work of his renovated instrument, he was himself engaged in a new enterprise of his own. Whether the recollection of what his friend Gassiot had done some twelve years before at Clapham—how, when he returned from his City work in the early evening, he retreated down to his laboratory, furnished at incredible labour and expense, and there tried to investigate the nature and origin of the electric discharge, and especially the strangely beautiful luminous striæ observed in tubes partially exhausted, visited now and then, while at work, by Faraday and other kindred spirits—whether or not this may have been the inducing cause, certain it is that De la Rue became fascinated by the same phenomena, and enamoured with the same pursuit. Possibly through a like scientific contagion, Spottiswoode also, in due course of time, endeavoured to wrest the same secret from Nature's hands. For years these three men worked and persevered in hope. None of them wholly succeeded, and yet none of them wholly failed; each and all left finger-posts to guide some future and more fortunate research.

The space which can be here afforded to the memoir even of an illustrious man precludes more than a passing allusion to the honours and social distinctions which always accompany the efforts of a life such as Warren de la Rue's; and upon him they were accumulated in abundance. The abiding honour lies in the contemplation of the man. A career like his dignifies the daily life of a manufacturer, giving it an aim and an object apart from the accumulation of wealth; it humanizes, warms, and illuminates the absorbing abstraction of the solitary student; and it illustrates the fact of an Aristocracy of Nature.

THE PHILOSOPHY OF MYSTICISM.

The Philosophy of Mysticism. By Carl du Prel, Dr. Phil. Translated from the German by C. C. Massey. 2 Vols. (London: George Redway, 1889.)

WE own to a certain mistrust when we are asked to accept goods under a trade-mark of mysticism; just as we have a most Levitical desire to pass by on the other side when we encounter the latest lucubrations of the circle-squarer, the absolute harmony of Genesis and geology, or when the last new theory of the soul is extended before us, "All Danaë to the stars." Now the philosophy of mysticism contains the latest of soul theories, or rather it is an old theory—a very old theory indeed—which has been newly adapted and furbished up and fitted with the very latest adjuncts which the outskirts of modern science can supply, so that it is to all intents and purposes just as good as if it were altogether new and original. Do not let us be misunderstood: both author and translator act in the strictest good faith. There is no false pretence about the matter. The whole work is perfectly ingenuous. The antiquity of the central idea is not in dispute, but it is claimed for the author that he has essentially modified our conception of that idea, that he presents his matter from a new stand-point, which is enough in all conscience nowadays, and that he is the first to show, by systematic analysis and comparison, that somnambulism and its cognate states are not essentially abnormal or morbid, but are in truth a mere exaltation of ordinary sleep, that the faculties evinced in those states are incipiently manifested also in dream, and are even indicated, though still more indefinitely, in waking life. It is contended that in this way the whole dream-life is reclaimed from its presumed worthlessness for scientific and philosophical purposes.

A duality of person with a unity of essence is the theory which commends itself to Baron du Prel, and he has worked out with much skill and acumen the details of an hypothesis to which his evident earnestness induces us to accord a hearing even when we are compelled to dissent from his conclusions. This hypothesis will have none of science, falsely so called; it sets at nought the accepted views of the physiologist and the materialist, and is a new, if nebulous, gospel of transcendental existence and apparently limitless progression. Man's life is moulded by his conception of his relation to the world, and that conception the present work is to radically revise. Who can tell if in the twentieth century the acceptance of these mystical views may not transform the present eager, struggling, money-grubbing crowd into a fraternity of peaceful philosophers finding in the placid pleasures of catalepsy an efficient substitute for the excitement of a boom in copper and for the fevered gambling of the Stock Exchange?

The author is very hard in his strictures upon the feeble physiologist, the wicked materialist, and indeed upon the modern professors of science generally, whom he abandons to their "exact amusements," whilst he seeks "the true theory in the bare analysis of the process which takes place in memory," and it is really wonderful what a superstructure he raises on the basis of that analysis. His preliminary dig at contemporary men of science he follows up with cuts and thrusts at intervals, but his salient grievance is that one and all fail to conceive progress otherwise than on their existing plane, whereas true progress must be inevitably vertical. With the advent of experimental methods, we learn, the world of science believed itself to have discovered a means for the attainment of all available knowledge, but the belief is erroneous. Not only is science still very far from its goal, but with the completion of its existing tasks, new prospects will be opened in the vertical direction. Should science succeed in explaining the whole visible world, that explanation is only as to a *represented* universe, a secondary phenomenon, a mere product of our sense and understanding, leaving the true world untouched. The quality of our consciousness in its relation to that world has still to be considered, and by such a method alone can its true nature be in any degree discovered. The visible world undergoes qualitative changes in the generation of consciousness, for, since the vibration of ether is in consciousness light and atmospheric vibration sound, it is evident that we are not truly cognizant of things, but only of the modes in which our senses react upon them. Taking all which and much more besides into consideration, the author sums up the result of human thought on the world-problem by saying that "consciousness does not exhaust its object, the world," a remark somewhat analogous to that of the Danish prince who observed that "there are more things in heaven and earth than are dreamt of in our philosophy."

As the world is the object of consciousness, so is the *Ego* that of self-consciousness; and here, says the Baron, materialism still flatters itself with the hope of reducing all psychology to physiology. It is deceived: self-consciousness does not exhaust its object, but is as inadequate to the *Ego* as consciousness is to the world, and the *Ego* may as much exceed self-consciousness as consciousness is exceeded by the world. The degree of the excess, is, however, not absolutely constant, since, by the rise of consciousness in the biological process, the boundary between the conscious and transcendental worlds has been and will be continually displaced. Of being, other than representation, we know nothing, and spirit is the primary and the real, for were its perceptive faculty changed, the whole material world of representation would be transformed; a clear demonstration that the represented world is a mere creature of the spirit. Behind consciousness is the ultimate being of which that consciousness is but the reflection, and as this ultimate being is beyond consciousness the Baron terms it the unconscious. This unconscious may either lie immediately behind the physically conditioned consciousness, or may be so indefinitely removed as to allow of an intermediate root of conscious individuality which is only relatively unconscious for the organism of sense. The author finds such an intermediary in his so-called psychophysical threshold of sensibility, which is the shifting barrier between the unconscious and self-consciousness. He conceives a dualism of consciousness, the division of two "persons" in one subject, but his conception differs from the popular conception of the dualism of soul and body, of matter and spirit, of Nature and supernatural. This dualism of consciousness is, with him, an intelligence which emerges with clearness and power just in proportion to the cessation of the organic functions with which the consciousness of waking life is associated; the two halves of our consciousness, divided by the movable threshold of sensibility, forming the subject which is an organizing as well as a thinking principle. The hypothesis of transcendental individuality co-existent with the earthly life and constructive of the organism by which consciousness is (from the earthly stand-point) dualized, necessitates the doctrine of pre-existence. Transcendental individuality implies a distinction from personal consciousness, and that the soul is not wholly plunged in the successive bodies which it constructs; the personal consciousness with its *Ego* being the mere partial and temporary limitation of a larger self, the growth of many seasons of earthly life.

The state of the individual after death is not precisely defined, but is suggested by the similitude of the smaller of two concentric circles expanding to the larger; the circumference of the inner circle being the organic threshold of sensibility, which death removes altogether, as it is already partially removed in such analogous states as sleep, somnambulism, &c. As in preoccupation the mind is concentrated to a focus, and subsequently expands to the limits of consciousness, so is earthly consciousness in death expanded to the boundary limits of the true *Ego*.

Transcendental subjectivity provides for continuity of consciousness, but the experience and whole activity of one of our objective life-times will be assimilated for results independent of those proposed by the contracted *Ego*, which bear but a minute proportion to the gradually accumulated content of the whole individual. The personal *Ego* must be brought to the point of view of the transcendental subject to which the mere happiness of that *Ego* is indifferent. What to us as persons are but high ideal motives may be alone of interest to the larger self which only maintains the organic personality for its own purposes. Such is Mr. Massey's analysis of the master's views, and it must be obvious that on this showing matters are decidedly in favour of the higher *Ego* which has, so to speak, got it all its own way. But since that exalted essence is, according to its moral nature, a product of development, the greater morality is not always on its side, for were that the case, terrestrial existence would have no educational value, and it is comfortable, therefore, to learn that our moral consciousness in earth-life can erect itself against its larger self, and may thus enrich the latter by the moral fruits of mundane existence; the struggle which takes place between the divisions of the subject being analogous to the process of Nature in its endeavour to expel disease, and drive whatever is morbid in an organism to the surface, or, to put it baldly, a species of spiritual measles. Such a theory, it is contended, fits the progress of the individual into the progress of the race, avoiding the waste of energy involved in the conception that the former is sacrificed to the latter, and supplies a wondrous harmony in which pessimism is subordinated to optimism.

The author is erudite, and he hails from the Fatherland; it is therefore not a matter for surprise that somewhat Shandean theories are exposed in sentences of wondrous construction. With these Mr. Massey has manfully wrestled; but, in his commendable desire to play the part of a faithful translator, he has at times given us such specimens of Teutonic English "as she is wrote" as render the good Baron's mysticism ten times more mysterious. We have read and re-read a passage, and a dozen perusals have left us still in doubt whether the meaning which the author and translator intended to convey were really grasped. Fidelity may be carried too far. At other times he who runs may read, and the author expresses his sentiments with an ingenuous frankness, as when he writes that "every criticism will be welcome which is adapted to advance the subject and myself."

Assuming that we have mastered the Baron's theory, an assumption we hesitate to make, we may place it before such of our readers as prefer a crude simile to the technicalities of metaphysics, in an illustration derived from natural history. Those who have visited the rock-pools of our coasts must have noticed the amusing little hermit crab (*Pagurus bernhardus*), who ensconces his soft unarmoured tail in the temporary shelter of an empty shell. He wriggles into his self-chosen habitation, and holds on to it with the pinchers with which his tail is provided, until he voluntarily leaves it before the approach of death. The hermit crab is the unconscious whole whose tail is tucked into the shell of self-conscious existence. As he emerges from it, or retires more completely, the amount of crab within the shell varies, the threshold of sensibility is shifted, and the shell benefits or suffers accordingly. The development of the moral nature of the subject, and its fitness for higher re-incarnation, are likewise shadowed forth in the fattening of the crab's tail, and his search for a roomy whelk-shell in place of the restricted covering of the modest periwinkle. Or, once again, the threshold of sensibility may be likened to the lid of the box from which the Jack of memory leaps, and upon the closure of which forgetfulness ensues.

It may be readily imagined that the author does not ask us to accept his theories unproven, and he has collected a mass of curious information from the most varied sources. Some of his anecdotes are oases of entertainment, which will, we fear, be missed by readers who do not, as we have done, peruse the volumes from cover to cover. As instances of our meaning, we may cite the case of a weak-minded youth upon whom all instruction in languages and science was thrown away, but who, after a fall on the head, became distinctly clever, intellectual, and highly cultivated, quickly seizing what he had been taught in vain before—a demonstration of the value of a box on the ears in the case of a stupid boy; the girl who, in her waking life, was reminded of her self-imposed somnambulistic treatment by the vision of a squirt; the military author who entered the barracks to take charge of the watch, in obedience to a dreamed order which he conceived to be a reality (had the case been one of neglect of a real order which he believed himself to have dreamt, we fear the court-martial would not have admitted the plea); or the wife who, subject to conditions of alternating consciousness, resented the presence of her husband, whom she treated with maidenly reserve. To prove the existence of a transcendental measure of time which is totally different from the normal, we are told of a flea-bite which occasioned a dream, concluding with a stab in the part of the body upon which the insect operated; of a pinch on the thigh, which caused the sleeper to imagine himself bitten by a wild beast; of De Quincey's opium dreams, which appeared to him to extend over vast periods of time; and of Mahomet, who, having knocked over a pitcher of water when translated by the Archangel Gabriel, viewed all things in heaven and hell, and held ninety thousand conferences with the Deity, returning to his still warm couch before the contents of the pitcher were expended. A somnambulistic girl exclaimed, "Where am I? I am not at home in the head. There is a strange struggle between the pit of the stomach and the head; both would prevail, both see and feel." So you see that "transcendental physiological functions seem to be parallel with corresponding changes in the ganglionic system." Authorities jostle in kaleidoscopic confusion; the "Novum Organum" standing cheek by jowl with the Bhagavadgita and the Vedas; whilst Aristotle and Proctor, Plato and Mrs. Crowe, Habakkuk, Galen, Plotinus, L. Oliphant, Daniel, Darwin, Kant, Olcott, and scores of others, jostle each other in ill-assorted series, but each with his contribution to the mosaic of marvels. On such a catena of evidence are based the two volumes; and, in spite of their waywardness, there is a thread of argument running through them which it would be unfair to the author to sunder by attempting an imperfect *précis* of his work, had we even the heart to impose it upon our readers. It has been said that, sooner or later, all books come into the hands of those for whom they were written, and there is no special reason for an exception in this case because the evidence for what is really a very beautiful theory fails to carry conviction to us. Doubtless our "threshold of sensibility" has gone wrong in some unaccountable way, and we have not enough of the Subject on this side of it to estimate the pearls of transcendentalism at their true worth. To the true adept, the work will doubtless prove wholly acceptable, and the author may take comfort in the reflection that "on this globe we serve an end, the attainment of which cannot be hindered, though all mankind conspired against it."

OUR BOOK SHELF.

A Treatise on Chemistry. By Sir H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S. Vol. III. The Chemistry of the Hydrocarbons and their Derivatives; or, Organic Chemistry. Part V. (London: Macmillan and Co., 1889.)

THE present and fifth part of the "Treatise on Organic Chemistry" is devoted to an account of the benzenoid compounds containing eight or more than eight atoms of carbon, and brings the subject down to the group of the terpenes and camphors, including india-rubber and gutta-percha.

The various compounds are, as the title of the work denotes, grouped about the hydrocarbons from which they are derived. Thus we have the styrolene group, the cumene group, the cymene group, and so on.

The present instalment of the work also describes numerous instances of the interesting class of benzenoid compounds containing closed lateral chains in the ortho-position, *i.e.* with the two ends of the chain attached to carbon atoms which in their turn are directly united with one another. Such compounds are, for example, the indoles, the indazoles, isatin, carbostyril, and coumarin.

The subject of closed-chain compounds has of late years possessed a peculiar fascination for organic chemists, and the reason of this is not far to seek; for, apart from the fact that many of the closed-chain derivatives of benzene, such as coumarin, isatin, and indole, either occur in nature or are the immediate derivatives of naturally occurring compounds, many chemists believe that various important problems in chemical statics may ultimately be solved by the study of these compounds. At present chemists do not altogether know why, for example, closed lateral chains of carbon atoms should occur only in the ortho-position, and never in the meta- or para-position; why such closed lateral chains never contain less than five or more than six carbon atoms; and why it has never been found possible to unite any single polyad atom to two contiguous (ortho) carbon atoms in benzene, whilst in paraffinoid compounds such a union may be effected. But when these questions have been answered, something will be known concerning the local distribution of the affinities of the ultimate atoms; and meanwhile the ingenious hypothesis of Van 't Hoff with regard to the position of the affinities in the carbon atom is a step in the right direction, and affords what is possibly more than a merely provisional answer.

The authors have also given a very full account of Wallach's interesting researches on the terpenes, and here, as elsewhere, the information is thoroughly up to date.

The instructive historical introductions prefixed to the descriptions of important compounds and groups of compounds, referred to in our notices of previous portions of the work, are continued.

Solutions of the Examples in a Treatise on Algebra. By Charles Smith, M.A. (London: Macmillan, 1889.)

THE value of such a book is great both to teachers and students. The former, as we have often pointed out, have scant leisure for working out the more elaborate questions which nowadays have place even in elementary treatises, or scarcely care to refer to their notes, which are never, unless they are exceptionally methodical men, to be found when wanted; the latter are, by means of such a work as the one before us, in a great measure rendered independent of outside aid. Though Mr. Smith's solutions are marvels of compressed diction in many cases, they yet are, we can certify from an extended examination of all parts of the subject, expressed with all the clearness required. In a few cases two solutions are given; this is an advantage, for often we have found the second solution very suggestive. We have, then, here an excellent corpus of solutions of questions, which have been considered by many competent judges to be well arranged and well calculated to draw out a student's powers in this part of mathematics. We have come across a few typographical errors (there is one on the last page), but they are in most cases easily detected on following out the solution.

Applied Mechanics. By D. A. Low. (London: Blackie and Son, 1889.)

THIS is an excellent little text-book, treating of those parts of the subject which the Science and Art Department require for the elementary stage. There are, however, specially marked articles which may be read by advanced students.

The author has taken, as the ground-work of the book, the notes which he has used for many years in his classes with much success. Much care has been taken with those pages relating to mechanism. The diagrams are especially good, and the descriptive portions accompanying them are clear and concise. A striking and most useful feature will be found in the unusually large number of examples following each chapter, typical examples also being worked out between the articles.

The last half-dozen chapters are devoted to the nature, use, and strength of materials used for purposes of construction, and the different kinds of stress to which they may be subjected. The syllabus issued by the Department for teachers in this subject, followed by the examination papers of recent years, is appended. The book is one which can be recommended, and will no doubt be well received by teachers and students alike. G. A. B.

Northern Afghanistan. By Major C. E. Yate, C.S.I., C.M.G. (Edinburgh and London: Blackwood, 1888.)

IN this volume the author has brought together a number of letters written from the Afghan Boundary Commission, and he explains that they are now published in a connected form as a sequel to his brother Captain A. C. Yate's book, entitled "England and Russia Face to Face in Asia." A large part of the work relates chiefly to matters of political interest; but there are also excellent descriptions of the various places which Major Yate visited, and of the people with whom he came in contact. His account of Herat and the shrines in the neighbourhood is particularly good; and Balkh, of which he gives a plan, he depicts concisely and clearly. Of the desert from Andkhui to the Oxus he says it is about as hot and wretched a country as he ever saw. In this desert, wherever a few inches of mud and water were left, he used to see the white-breasted pintail sand-grouse coming to drink in small numbers; but with that exception he saw no sign of game. Lizards of all sizes and colours were to be seen. A lizard, some 2 or 3 feet long—"of a yellowish colour with red stripes"—seems to have especially attracted Major Yate's attention. This animal "never tries to run away, but stands and hisses, distending its stomach to an abnormal size." The dog hates it cordially; and very naturally, for, when the dog is approaching to the attack in front, "the lizard suddenly brings his tail round and gives the unwary dog a most tremendous wipe across the side of the head." "The first interview between a dog and one of these animals is very amusing—the dog is always so utterly astonished at this unexpected attack on the lizard's part, and also so hopelessly wroth." We may note that in a pocket at the end of the volume there are two maps—a map of the north-west frontier of Afghanistan, and a sketch-map showing the routes traversed by the Boundary Commission during 1884, 1885, and 1886.

By Leafy Ways. By Francis A. Knight. (London: Elliot Stock, 1889.)

THIS volume is made up of "brief studies," which originally appeared as articles in the *Daily News*. The author's object is not to present scientific conclusions about Nature, but to convey some idea of the impressions which have been produced upon him by various elements of the external world. He is an ardent lover of everything in Nature that appeals to what may be called the artistic sense; and he has the secret of suggesting, by means of brief and simple descriptions, very vivid pictures of scenes in which he himself has found delight. No one who wants to be intellectually instructed should trouble himself to read the volume; but it will give much pleasure to persons who like to be reminded of some of the innumerable aspects in which the country reveals itself to sympathetic observers. The volume is prettily illustrated by E. T. Compton.

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.*]

On an Electro-magnetic Interpretation of Turbulent Liquid Motion.

THE equations of rate of increase of momentum F, components X, Y, Z, per unit volume of a liquid (density = 1) are—

$$X = \frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz} + \frac{dp}{dx},$$

and corresponding terms for Y and Z. If the liquid be incompressible,

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0.$$

Mulip ying this by u, and adding to X, we get—

$$X = \frac{du}{dt} + \frac{d}{dx}(u^2) + \frac{d}{dy}(uv) + \frac{d}{dz}(uw) + \frac{dp}{dx},$$

and similar ones for Y and Z.

It is at once obvious that these could be written down at once, for u^2, uv, and uw are the momenta per second carried into the element through its faces as in the kinetic theory of gases; and it is evident that the equation is the same as for a strained solid where these are the superficial normal and tangential forces.

If we now take the average values of these throughout any small region, and write for the average of $\frac{du^2}{dx} = \frac{\overline{du^2}}{dx}$, we have—

$$\overline{X} = \frac{du}{dt} + \frac{\overline{du^2}}{dx} + \frac{\overline{duv}}{dy} + \frac{\overline{duw}}{dz} + \frac{dp}{dx}.$$

Comparing this with Maxwell's stress in the ether, we must take ("Electricity and Magnetism," vol. i. § 105)—

$$\frac{\overline{du^2}}{dx} = \frac{d}{dx}\cdot\left(\frac{d\psi}{dx}\right)^2 - \frac{d}{dx}(Q^2 + R^2 - P^2) - \frac{d}{dx}(\beta^2 + \gamma^2 - \alpha^2),$$

$$\frac{\overline{duv}}{dy} = \frac{d}{dy}\left(\frac{d\psi}{dx}\cdot\frac{d\psi}{dy}\right) + \frac{d}{dy}PQ + \frac{d}{dy}\cdot\alpha\beta,$$

$$\frac{\overline{duw}}{dz} = \frac{d}{dz}\left(\frac{d\psi}{dx}\cdot\frac{d\psi}{dz}\right) + \frac{d}{dz}PR + \frac{d}{dz}\cdot\alpha\gamma;$$

adding these together, and comparing with the equation for X, we get—

$$\overline{X} - \frac{\overline{du}}{dt} - \frac{dp}{dx}$$

$$= \tfrac{1}{2}\frac{d}{dx}\left\{\left(\frac{d\psi}{dx}\right)^2 + \left(\frac{d\psi}{dy}\right)^2 + \left(\frac{d\psi}{dz}\right)^2\right\} + \frac{d\psi}{dx}\left\{\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} + \frac{d^2\psi}{dz^2}\right\}$$

$$+ P\left(\frac{dP}{dx} + \frac{dQ}{dy} + \frac{dR}{dz}\right) - Q\left(\frac{dQ}{dx} - \frac{dP}{dy}\right) + R\left(\frac{dP}{dz} + \frac{dR}{dx}\right)$$

$$+ \alpha\left(\frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz}\right) - \beta\left(\frac{d\beta}{dx} - \frac{d\alpha}{dy}\right) + \gamma\left(\frac{d\alpha}{dz} - \frac{d\gamma}{dx}\right),$$

and two similar ones involving Y and Z.

Now, assuming

$$-p = \tfrac{1}{2}\left\{\left(\frac{d\psi}{dx}\right)^2 + \left(\frac{d\psi}{dy}\right)^2 + \left(\frac{d\psi}{dz}\right)^2\right\},$$

and

$$\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} + \frac{d^2\psi}{dz^2} = 0,$$

$$\frac{dP}{dx} + \frac{dQ}{dy} + \frac{dR}{dz} = e,$$

$$\frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} = m,$$

we get—

$$X - \frac{\overline{du}}{dt} = Pe + \alpha m - Q\left(\frac{dQ}{dx} - \frac{dP}{dy}\right) + R\left(\frac{dP}{dz} - \frac{dR}{dy}\right)$$

$$- \beta\left(\frac{d\beta}{dx} - \frac{d\alpha}{dy}\right) + \gamma\left(\frac{d\alpha}{dz} - \frac{d\gamma}{dy}\right),$$

and two other similar ones.

If we now *assume* as the relations connecting P, Q, R and α, β, γ with a velocity V—

$$V\left(\frac{dR}{dy} - \frac{dQ}{dz}\right) = \frac{d\alpha}{dt} \text{ and } V\left(\frac{d\gamma}{dy} - \frac{d\beta}{dz}\right) = -\frac{dP}{dt},$$

and the corresponding others, we get—

$$X - \frac{\overline{du}}{dt} = Pe + \alpha m + \frac{1}{V}\cdot\frac{d}{dt}(Q\gamma - R\beta),$$

which, if we suppose the motion steady, so that $\frac{du}{dt} = 0$ gives exactly the right expression for the mechanical force due to an electric charge, e, and a magnetic charge, m, and to an electric current with components $\frac{dP}{dt}, \frac{dQ}{dt}, \frac{dR}{dt}$.

In order to justify the assumed relation between α, β, γ and P, Q, R, compare with Sir William Thomson's equations of propagation of disturbance in a turbulent liquid (*Phil. Mag.*, October 1887, p. 342).

In his case everything is a function of y only, and in that case my equations become, when there is no mechanical force—

$$\frac{\overline{du}}{dt} = \frac{1}{V}\frac{d}{dt}(R\beta - Q\gamma),$$

$$= Q\frac{dP}{dy} - R\frac{dR}{dy} + \beta\frac{d\alpha}{dy} - \gamma\frac{d\gamma}{dy}.$$

Now under the circumstances contemplated, R and γ are not functions of y—

$$\therefore \frac{\overline{du}}{dt} = Q\frac{dP}{dy} + \beta\frac{d\alpha}{dy}.$$

If we now assume that during the passage of a disturbance of the kind $Q = \beta =$ constant, and they must be if

$$\frac{dP}{dx} + \frac{dQ}{dy} + \frac{dR}{dz} = \frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} = 0,$$

we get—

$$\frac{d\overline{u}}{dt} = \frac{d}{dy}(PQ) + \frac{d}{dy}(\alpha\beta) = \frac{d}{dy}(PQ + \alpha\beta),$$

and consequently—

$$\frac{d}{dt}(R\beta - Q\gamma) = V\frac{d}{dy}(PQ + \alpha\beta).$$

Comparing this with Sir William Thomson's equation (34) we see that—

$$f = -\frac{R\beta - Q\gamma}{V}, \quad xzav(uv) = PQ + \alpha\beta).$$

Similarly, by calculating

$$\frac{d}{dt}(PQ + \alpha\beta) = Q\frac{dP}{dt} + \beta\frac{d\alpha}{dt}$$

$$= -QV\cdot\frac{d\gamma}{dy} + \beta V\frac{dR}{dy} = +V\frac{d}{dy}(R\beta - Q\gamma),$$

we reproduce Sir William Thomson's equation (49), if $V^2 = \frac{2}{9}R^2$, *i.e.* be $\frac{2}{9}$ of the average square of velocity of turbulency. This V is the velocity of propagation of the disturbance.

If we wish to identify this laminar motion of Sir William Thomson's with a simple wave propagation such as light consists of, we must take $Q = \beta =$ constant, and then the two equations are satisfied by—

$$\frac{dP}{dt} = -V\frac{d\gamma}{dy} \text{ and } \frac{d\gamma}{dt} = -V\frac{dP}{dy},$$

and

$$\frac{dR}{dt} = V\frac{d\alpha}{dy} \text{ and } \frac{d\alpha}{dt} = V\frac{dR}{dy},$$

no matter what Q and β are, and these are, of course, Maxwell's equations. There is nothing to settle which is the electric and which the magnetic disturbance, nor even which, f or $xzav(uv)$, is proportional to $R\beta - Q\gamma$, and which to $PQ + \alpha\beta$, but the consideration that electric currents and electrification are possible while magnetic currents do not exist, will probably decide a question of this kind. In Maxwell's simplest wave, P and γ only exist, and in this case, as I have assumed above, $xzav(uv)$ would correspond to electric, and f to magnetic disturbance. In Sir William Thomson's representation, $xzav(uv)$ is of the nature of a twist, and f of a flow, contrary to the usual notion that magnetic force is twisty. However, a flow cannot take place outwards continuously from a body, so that there seems a reasonableness in likening electrification to a twist. The fact that magnetism in matter rotates the plane of polarization sometimes to one side and sometimes to the other does not prove conclusively that it is a rotation: a flow might confer that property on matter.

In order to include the general case of a variable state, an interpretation of X, Y, Z, is required. Where no matter is present, we must assume—

$$-X = \frac{dp_1}{dx} + \frac{1}{2}\frac{d}{dx}(P^2 + Q^2 + R^2 + \alpha^2 + \beta^2 + \gamma^2), \text{ \&c.},$$

and in the steady state—

$$p_1 = -\frac{1}{2}(P^2 + Q^2 + R^2 + \alpha^2 + \beta^2 + \gamma^2).$$

When the state is not steady, we have, if

$$\frac{dP}{dx} + \frac{dQ}{dy} + \frac{dR}{dz} = e, \quad \frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} = m,$$

$$X - \frac{d\overline{u}}{dt} = +Pe + \alpha m + \frac{d}{dt}\frac{(Q\gamma - R\beta)}{V}, \text{ \&c.}$$

We must assume that p_1 has no longer the above value; but by differentiating the first of these with respect to x, the second with respect to y, and the third with respect to z, we get—

$$\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} - \frac{d}{dt}\left(\frac{d\overline{u}}{dx} + \frac{d\overline{v}}{dy} + \frac{d\overline{w}}{dz}\right)$$

$$= +\left(e^2 + P\frac{de}{dx} + Q\frac{de}{dy} + R\frac{de}{dz}\right) + \left(m^2 + \alpha\frac{dm}{dx} + \beta\frac{dm}{dy} + \gamma\frac{dm}{dz}\right)$$

$$-\frac{1}{2}\frac{1}{V^2}\frac{d^2}{dt^2}(P^2 + Q^2 + R^2 + \alpha^2 + \beta^2 + \gamma^2),$$

which is satisfied by $e = 0$, $m = 0$; or if e and m exist, by—

$$e^2 + P\frac{de}{dx} + Q\frac{de}{dy} + R\frac{de}{dz} = 0;$$

and

$$m^2 + \alpha\frac{dm}{dx} + \beta\frac{dm}{dy} + \gamma\frac{dm}{dz} = 0;$$

and

$$\frac{d\overline{u}}{dx} + \frac{d\overline{v}}{dy} + \frac{d\overline{w}}{dz} = 0, \quad \frac{d^2p_1}{dx^2} + \frac{d^2p_1}{dy^2} + \frac{d^2p_1}{dz^2} = 0;$$

and

$$\left(\frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2} - \frac{1}{V^2}\frac{d^2}{dt^2}\right)(P^2 + Q^2 + R^2 + \alpha^2 + \beta^2 + \gamma^2) = 0,$$

which means that energy is propagated with a velocity = V, and so the assumed relations connecting P, Q, R, and α, β, γ, mean little more than that the initial state is stable.

This, I think, shows that, so far, the ether may be a turbulent liquid.

If we compare the dimensions of the quantities involved in the theory of motion of a turbulent liquid with those in the electro-magnetic theory, we find it convenient to put these latter dimensions into the following forms, as they are the same on the electro-magnetic and electrostatic systems.

Calling $[K^{\frac{1}{2}}\mu^{\frac{1}{2}}] = [V^{-1}]$, and density $[\rho] = [ML^{-3}]$, we can write—

Electric displacement	$= [K^{\frac{1}{2}}\rho^{\frac{1}{2}}V]$
Electric force	$= [K^{-\frac{1}{2}}\rho^{\frac{1}{2}}V]$
Magnetic displacement	$= [\mu^{\frac{1}{2}}\rho^{\frac{1}{2}}V]$
Magnetic force	$= [\mu^{-\frac{1}{2}}\rho^{\frac{1}{2}}V]$.

It is at once evident that the products of the force and displacement are, in each case, of the dimensions of the P^2, Q^2, R^2, α^2, β^2, γ^2, involved in the theory I have already given.

I think it would be well, perhaps, to introduce some new quantities of zero dimensions to define the polarization of the medium. It seems likely that the velocity involved in P must depend on how intensely the turbulency is polarized, and could therefore be measured by a quantity of zero dimensions multiplied by a measure of the turbulency. This measure would be $\rho^{\frac{1}{2}}V$, so that, for electrostatic energy—

$$P^2 = P_0^2(\rho V^2),$$

and for electro-magnetic—

$$\alpha^2 = \alpha_0^2(\rho V^2),$$

where P_0 and α_0 were of zero dimensions.

In order to introduce the effect of alterations in material, we may put these in the form—

$$P^2 = \frac{\rho P_0^2}{K\mu}, \qquad \alpha^2 = \frac{\rho\alpha_0^2}{K\mu},$$

and then the electric displacement will be—

$$= \sqrt{\frac{\rho}{\mu}}\cdot P_0,$$

and the electric force—

$$= \sqrt{\frac{\rho}{\mu}}\cdot\frac{P_0}{K};$$

while the magnetic displacement will be—

$$= \sqrt{\frac{\rho}{K}}\cdot\alpha_0,$$

and the magnetic force will be—

$$= \sqrt{\frac{\rho}{K}}\cdot\frac{\alpha_0}{\mu}.$$

If we call the six quantities $\overline{u^2}$, $\overline{v^2}$, $\overline{w^2}$, $\overline{vw}$, $\overline{wu}$, $\overline{uv}$, a, b, c, f, g, h, they are connected with the six quantities P, Q, R, α, β, γ, and the three undisturbed values of $\overline{u^2} = A$, $\overline{v^2} = B$, $\overline{w^2} = C$, by the equations—

$$a = A + P^2 + \alpha^2, \text{ \&c.}, \quad f = QR + \beta\gamma, \text{ \&c.}$$

In order to examine how these are related, take an ellipsoid defined by—

$$ax^2 + by^2 + cz^2 + 2fyz + 2gzx + 2hxy = d,$$

and we see that, if $A = B = C = R$, as is the case except in a crystalline medium, the ellipsoid is—

$$R(x^2 + y^2 + z^2) + (Px + Qy + Rz)^2 + (\alpha x + \beta y + \gamma z)^2 = d;$$

so that, if $Px + Qy + Rz = L$, $\alpha x + \beta y + \gamma z = \lambda$.

$L + i\lambda$ and $L - i\lambda$ are the imaginary circular reactions of the ellipsoid,[1] and consequently the intersection of L and λ, whose direction cosines are proportional to $Q\gamma - R\beta$, &c., is the major axis of the ellipsoid, when the above signs are attributed to L^2 and λ^2. As any ellipsoid can be expressed in this form by referring it to its circumscribing sphere and the corresponding planes of circular section, it is apparent that any polarized state of the turbulent motion can be built up of P, Q, R, and α, β, γ, polarizations. The axis of the ellipsoid mentioned above represents the flow of energy in the medium during the propagation of a disturbance.

I am inclined to think that Sir William Thomson's fear that diffusion would vitiate these investigations would be avoided either by supposing the turbulent liquid to consist of interlocked vortex rings, or of infinite intercrossing lines; and in either case a natural hypothesis would be that matter consisted of free vortex rings. GEO. FRAS. FITZGERALD.

Trinity College, Dublin, April 26.

[1] This was remarked to me by Prof. Lyle, of Melbourne, while I was recently speaking to him upon this subject.

The New Eruption of Vesuvius.

ON April 29, 30, and May 1, a constant series of explosions (*boati*) and rumblings accompanied by earthquakes, which shook the southern foot of Vesuvius, were very noticeable at Resina. About 2 a.m., on May 2, part of the new cone of eruption (formed during the last ten months) fell in, showing that the internal support of the lava column had been removed, in consequence of this filling the new dyke, the formation of which had given origin to the preceding sonorous and mechanical disturbances. On the same day at 3 p.m. the lava sank still lower in the conduit on account of the dyke reaching the surface at the upper part of the great cone. More of the eruptive cone crumbled in, and of course simultaneously a considerable outpour of lava took place from the dyke fissure which is situated on the south-east side of the great cone. This outflow soon formed a long tongue of lava reaching to the Pedimentina or lower.

My friend Mr. George Bidder, Jun., who is studying at the Zoological Station here, was fortunately able to visit the mountain yesterday (May 3), and much of the information in this letter I have to thank him for. Unfortunately the extremely bad weather has prevented the upper part of the mountain being examined, so that accurate information as to the position and length of the fissure has not been obtainable; I hope, however, to make the ascent to-morrow, and will then send a more detailed account for your next issue. So far as the facts at hand are available, it would appear that this eruption is of small importance, being an analogue of that of May 2, 1885, and that, therefore, the lava will hardly reach cultivated ground.

A short glimpse of the summit of the mountain this evening shows that much of the eruptive cone still exists, whilst the reflection from the flowing lava is much feebler than yesterday evening. Lastly, a single faint glimmer this evening at the vent demonstrates the fact that the lava has not sunk very deep in the chimney. The eruption, or more properly *disruption*, was coincident with a marked barometric depression.

Naples, May 4. H. J. JOHNSTON-LAVIS.

The Sailing Flight of the Albatross.

I have been much interested by the letter of Mr. A. C. Baines (NATURE, May 2, p. 9) upon this subject. In the year 1883 ("The Soaring of Birds," NATURE, vol. xxvii. p. 534) I suggested that the explanation of these puzzling performances might be found in the increase of wind with height. To take advantage of this, the bird must rise against the wind and fall with it; but, at the time referred to, I had before me only the observations of Mr. Peal, in Assam, on the flight of pelicans, in which this feature is not alluded to. In Mr. Baines's observations, the omission is supplied, and there seems little reason to doubt that the true explanation of the flight of the albatross has been arrived at. In the case of the pelican soaring to a great elevation, it is less easy to understand how the differences of horizontal velocity can be sufficient.

Reference may be made to a paper by Mr. H. Airy (NATURE, vol. xxvii. p. 590), in which the matter is further discussed. Similar views have also been put forward more recently by an American author, whose name I have, unfortunately, forgotten.

Terling Place, Witham, May 6. RAYLEIGH.

"Giphantia."

IN a curious little work, entitled "Giphantia," the full title of which I subjoin, there is, at pp. 95–98, a passage that may have some interest in connection with the early history of photography, and of which I therefore subjoin a copy.

The Camp, Sunningdale, April 29. J. D. HOOKER.

"Giphantia: or, a View of what has passed, what is now passing, and, during the Present Century, what will pass, in the World." Translated from the Original French, with Explanatory Notes. (London: Printed for Robert Horsfield, in Ludgate Street, 1761.)

"Thou knowest that the rays of light, reflected from different bodies, make a picture and paint the bodies upon all polished surfaces, on the retina of the eye, for instance, on water, on glass. The elementary spirits have studied to fix these transient images: they have composed a most subtile matter, very viscous, and proper to harden and dry, by the help of which a picture is made in the twinkle of an eye. They do over with this matter a piece of canvas, and hold it before the objects they have a mind to paint. The first effect of the canvas is that of a mirrour; there are seen upon it all the bodies far and near, whose image the light can transmit. But what the glass cannot do, the canvas, by means of the viscous matter, retains the images. The mirrour shows the objects exactly; but keeps none; our canvases show them with the same exactness, and retains them all. This impression of the images is made the first instant they are received on the canvas, which is immediately carried away into some dark place; an hour after, the subtile matter dries, and you have a picture so much the more valuable, as it cannot be imitated by art nor damaged by time. We take, in their purest source, in the luminous bodies, the colours which painters extract from different materials, and which time never fails to alter. The justness of the design, the truth of the expression, the gradation of the shades, the stronger or weaker strokes, the rules of perspective, all these we leave to nature, who, with a sure and never-erring hand, draws upon our canvases images which deceive the eye and make reason to doubt, whether, what are called real objects, are not phantoms which impose upon the sight, the hearing, the feeling, and all the senses at once.

"The Prefect then entered into some physical discussions, first, on the nature of the glutinous substance which intercepted and retained the rays; secondly, upon the difficulties of preparing and using it; thirdly, upon the struggle between the rays of light and the dried substance, three problems, which I propose to the naturalists of our days, and leave to their sagacity."

Geological Photography.

IN the report of the Annual Conference of Delegates of Corresponding Societies of the British Association (*vide* NATURE, vol. xxxix. p. 187), reference is made to the proposed appointment of a Committee to collect and register photographs of localities, sections, or other features of geological interest in the United Kingdom. Several Societies have already attempted local photographic surveys, but the need is felt to secure uniformity of action by all the Societies interested, and to arrange for the photographs to be available for teaching and other purposes when needed. In order that steps may be taken to arrange for the practical working of the proposed scheme at the forthcoming meeting of the British Association at Newcastle, I am desirous of invoking the kind aid of those of your readers who have interested themselves in the photography of local geological features (especially of typical and temporary sections) in favouring me with the following information:—

(1) A list of photographs already taken, illustrating given localities or sections; and

(2) The names of local Societies, or persons who are willing to arrange for a photographic survey for geological purposes in their district.

The information afforded me will be placed before the Geological Section of the British Association at their next meeting, and I trust to receive many offers of valuable assistance from different parts of the country. If copies of photographs are sent me they will be carefully kept for exhibition at the meeting. Several geological friends have favoured me with suggestions in regard to size of photograph, scales of height, length, and other details, which will all be carefully considered. Photography is now so popular and easy of accomplishment that there should be no difficulty in organizing local photographic surveys for the purpose I have indicated.

It was arranged at Bath that the delegates should get their Societies to think the matter over, and that I should meanwhile endeavour to prepare a list of local geological photographs already available for study. I am communicating with the Societies with this object, but your insertion of this letter will further aid me in directing attention to the subject over a wider circle than I am able to reach. OSMUND W. JEFFS.

12 Queen's Road, Rock Ferry, Cheshire, April 23.

Columnar Structure in Ice.

I HAVE just read Mr. James McConnel's interesting and important paper on the plasticity of ice (NATURE, vol. xxxix. p. 203), and as he remarks that it would be interesting to know whether the columnar structure he describes as occurring in the ice of the St. Moritz Lake has been observed in England, I venture to ask you to record the fact that I recollect seeing a precisely similar structure in the ice of the lake in Kew Gardens in February 1880. The phenomenon occurred *during a thaw* that preceded by a day or two the memorable snowstorm of that month, and the aspect of the ice, where it had been broken through, recalled to my mind that of the well-known fossil *Lithostrotion basaltiforme*, as it was built up of vertical columns, irregularly hexagonal in section, about a quarter of an inch in diameter and of equal length with the thickness of the ice, about 4 or 5 inches. If I remember aright, bright sunshine had been thawing the ice during the day. I made a note on the occurrence at the time, but as I came to India shortly after I do not know what has become of it.

T. D. LA TOUCHE,
Geological Survey of India.

Camp near Cherrapunji, Assam, March 4.

Brilliant Meteor.

I SEND you an account of a meteor I saw on Saturday evening last, thinking it may interest others as much as it has myself. I was lamp-signalling at the time (8.55 p.m.), and saw far the largest meteor I have ever seen. It was far brighter than any planet, or even than a good rocket. It seemed to start from the Great Bear, and fall in a north-east direction half-way to the horizon. I immediately stopped my message, and asked my companion (a mile distant) if he had seen the meteor. He replied he had not, which surprised me, though he had the town lights not far behind him, and he was looking away from the north-east. I had not finished asking him about the meteor, when I heard a loud but distant report, which I can only put down to the same source. It sounded like distant artillery, or more particularly like a six-pounder at six miles distance on a still evening. The interval of time between the sight and the sound I should estimate at a minute. T. HERBERT CLARK.

Wingfield, Trowbridge, April 30.

A New Mountain of the Bell.

HAVE the kindness to correct two typographical errors in my communication describing the "New Mountain of the Bell," printed in your issue of April 25. On p. 607, col. 2, line 7, an unfortunate superfluous comma after the word quartz should be expunged, so as to read quartz pebbles and veins.

Near the bottom of the same column "modern gong" should read "wooden gong." As a matter of fact the *Nagous* is far from "modern." It consists of a heavy plank nearly 2 inches thick, 14 feet long, and suspended by ropes at two points 4 feet from either end. When struck with a wooden mallet, this primitive gong emits a loud sound. At the Monastery of St. Catherine, three of these are in use, one small one to call to their noonday meal the numerous *cats* which inhabit the rambling old building. H. CARRINGTON BOLTON.

London, May 1.

KLEIN'S "IKOSAHEDRON."[1]

IT has recently been said, with great truth, that pure mathematics is at the present moment the most progressive of all the sciences. It is, we must confess with sorrow, equally true, that the means at the disposal of English pure mathematical students for making themselves familiar with the recent advances in their science are deplorably scanty. This is not the place to discuss the reasons why it has so long been the case in this island that the stars of our mathematical firmament have been

"*Étoiles qui filent, filent et disparaient!*"

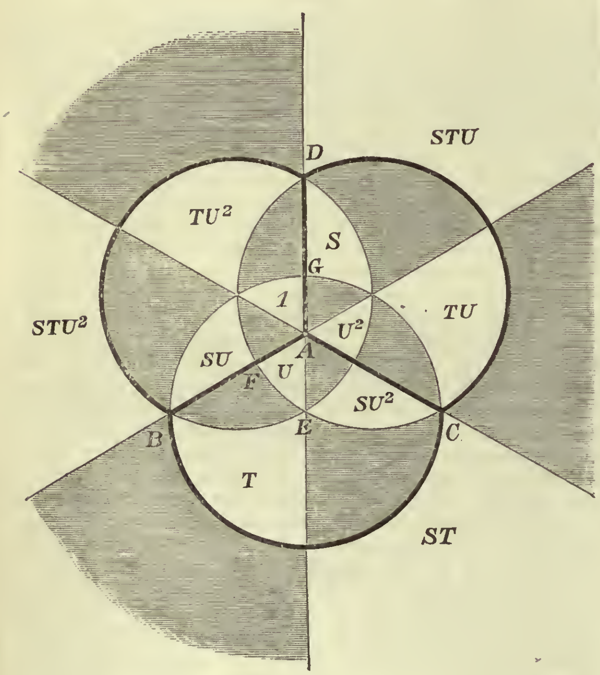
and not fixed suns, with minor but still useful bodies around them, receiving their light and completing their systems. But it is obvious that this shortcoming has been closely associated with the backward state of our text-book literature in pure mathematics. There exist in the English language so few books through whose pages the reader can so much as descry the frontier land of pure mathematics that every addition is an event of importance. Such an addition is Mr. Morrice's translation of Klein's "Ikosahedron." Klein's book is in many respects the most charming piece of modern mathematical writing that has appeared for many a day. It is a rare combination of great originality with wide and far-reaching views, Teutonic minuteness of scholarship, and a candour in dealing with the work of others which does not always accompany the other high qualities just mentioned. If we were asked to name a single book that would beyond others give the reader a comprehensive glance over the wide field of modern pure mathematics, and give him an introduction to this study which would at once both interest and instruct him, we should without hesitation name Klein's "Ikosahedron." The work interweaves, in a singularly felicitous and natural way, the most remote and apparently unconnected branches of higher pure mathematics. In the course of its perusal the reader will make acquaintance with the geometry of the regular solids, the theory of substitutions, the theory of functions of a complex variable, invariants, the theory of linear differential equations, Riemann's researches on the hypergeometric series, Galois's theory of the resolution of algebraic equations, elliptic functions, Plücker's line geometry, and the special theory of quintic equations. This enumeration will sufficiently indicate the wide sweep of the work; but let not the reader be alarmed. If he is ignorant of all these subjects, so much the more will he enjoy the pleasure of Prof. Klein's introduction to them. He will find that he is led, by easy and pleasant ways, first to see the interest and importance of these subjects, then to panoramic aspects of them, and finally to just so much detail as will make him (if he be right-minded) thirst for more. Speaking from past experience, we should say that one of the greatest disadvantages of modern specialism is the repulsive force which it establishes at every point to the entrant. Let an English student sit down, for example, to Jordan's "Théorie des Substitutions." He is at once plunged into a sea of new terms and definitions. He is baffled by a kaleidoscopic array of subtle distinctions between con-

[1] "Lectures on the Ikosahedron, and the Solution of Equations of the Fifth Degree." By Felix Klein. Translated by George Gavin Morrice, M.A., M.B. (London: Trübner and Co., 1888.)

ceptions that are unfamiliar to him. He toils through the solution of abstract problems whose formulation he imperfectly grasps, and whose interest and importance he has not been permitted to see beforehand. The very beauty and logical rigour of the work is a hindrance to him; it entangles and suffocates him at the outset. And yet M. Jordan's work could not be otherwise, could not be better for its purpose, could not be dispensed with. But let the learner first read Klein's "Ikosahedron." He will there see the substitution theory first applied in simple cases with concrete illustration, and will then be led by degrees to see its all-embracing character. Then let him return to Jordan, and he will say of the theory of substitution,

"Her loveliness I never knew,
Until she smiled on me."

Under ordinary circumstances, any detailed analysis of a mathematical work would be out of place in the pages of NATURE. The appearance of the "Ikosahedron" in English is, however, an event of such importance that it would be wrong to miss the opportunity of giving the



English mathematical world some account, however imperfect, of its contents.

The proper subject of the work may be said to be the general theory and applications of functions which are transformable into themselves (*i.e.* are unaltered) by a finite group of substitutions. By a *group* of substitutions, or indeed of any operations whatsoever, is meant a complete set of operations of such a nature that the combination of any two or more of them is equivalent to some one of the set. The number of operations in a group is called its order, and the order may in general be finite or infinite. A leading feature of Klein's work, indicated by its title, is the geometrical connection which he establishes between certain groups of substitutions, and the rotations which cause a regular solid to return into itself. It is obvious beforehand that the totality of such rotations for any given regular solid forms a group of finite order, for any two successive rotations of the kind may be replaced by a single one. The accompanying figure will make the connection plain. It represents the stereographic projection of the traces on a circumscribed sphere made by the planes of symmetry of a regular tetrahedron, A B C D, the vertex of projection being the antipodal point to A, and the plane of projection the diametral plane of which A is the pole. The spherical surface is obviously divided by the planes of symmetry into twelve (non-shaded) congruent triangles, and twelve other (shaded) congruent triangles, each of which is the image of one of the former in a plane of symmetry. These triangles lie in sets of $\nu_2 = 2$ about points such as F, which correspond to mid-edges of the tetrahedron, in sets of $\nu_2 = 3$ about points such as E, which correspond to centroids of the faces, and in sets of $\nu_3 = 3$ about the points which correspond to vertices of the tetrahedron. It is farther obvious that any one of the unshaded triangles can be transformed into each of the other twelve unshaded triangles by one of the group of N = 12 rotations which cause the tetrahedron to return into itself. If we mark one of these by inscribing 1, and if S denote a rotation of period 2 (*i.e.* of angular magnitude $2\pi/2$) about G, T a rotation of period 2 about F, and U a rotation of period 3 about A, then the rotations by which the region 1 is transformed into the other twelve are—

$$1, U, U^2, S, SU, SU^2, T, TU, TU^2, ST, STU, STU^2;$$

and these give the twelve rotations of the tetrahedral group expressed succinctly in terms of three of them.

The same holds for the shaded triangles. Hence, if we pair each non-shaded triangle with a shaded one, and thus form a *fundamental domain*, then we see that any point within such a domain (boundary and summit points excepted) is transformed by the N tetrahedral rotations into N other points, one of which lies in each of the N domains. (Here we count the transformation of the point into itself, viz. the rotation represented by the identical symbol 1.) We pass over the questions that arise regarding the composition of a group and the conception of the extended group which embraces reflections in the planes of symmetry as well as rotations, and merely mention that a similar theory is established for the dihedron, *i.e.*, the figure composed of a great circle of the sphere divided into n equal parts, the octahedron, and the ikosahedron, the characteristic numbers being given by the following table:—

	ν_1	ν_2	ν_2	N
Dihedron ...	2 ...	2 ...	n ...	$2n$
Tetrahedron ...	2 ...	3 ...	3 ...	12
Octahedron ...	2 ...	3 ...	4 ...	24
Ikosahedron ...	2 ...	3 ...	5 ...	60

The next step is to connect each point on the sphere with the value of a complex variable z, or with the ratio of two complex variables $z = z_1/z_2$. This is done, after the manner of Riemann, by representing $z = x + yi$ in an Argand-diagram on the diametral plane of the sphere, and then projecting the point (x, y) stereographically upon the sphere. The point on the sphere is then spoken of as the point (z) or (z_1, z_2).

It is next shown that every dihedral, tetrahedral, octahedral, or ikosahedral rotation is equivalent to a non-homogeneous linear substitution of the form—

$$z' = (Az + B)/(Cz + D),$$

or to one or other of two pairs of homogeneous substitutions of the form—

$$z_1' = Az_1 + Bz_2, \; z_2' = Cz_1 + Dz_2;$$

and the proper values of A, B, C, D are calculated for each case.

If we consider the values of z corresponding to a point, and the N − 1 other points into which it is transformed by the N polyhedral rotations, we see that they are the roots of an algebraical equation of the Nth degree, say $Z \equiv f(z) = c$, the characteristic Z of which must have the property of remaining unaltered by every one of the N non-homogeneous substitutions. And there must likewise exist homogeneous integral functions of $F(z_1, z_2)$ of the Nth degree in the two variables z_1, z_2, containing one arbitrary parameter, which remain unaltered, to a factor *près*, for each of the group of 2N homogeneous polyhedral substitutions. The functions of the latter kind ("ground forms") are first determined. First, a special function F_1 (of degree N/ν_1 is determined, such that $F_1 = 0$ gives one of the ν_1 summits on the sphere, and the $N/\nu_1 - 1$ other points into which it is transformed by the polyhedral rotations. Then $F_1^{\nu_1}$ is a particular function having the property sought for. By an elegant application of the theory of invariants, two other functions, F_2 and F_3, corresponding respectively to the ν_2 and ν_3 summits, are derived from F_1. We then have for the general invariant function required—

$$\lambda_1 F_1^{\nu_1} + \lambda_2 F_2^{\nu_2} + \lambda_3 F_3^{\nu_3},$$

which contains only one arbitrary parameter, since there is in each case an identity of the form—

$$\lambda_1^{(0)} F_1^{\nu_1} + \lambda_2^{(0)} F_2^{\nu_2} + \lambda_3^{(0)} F_3^{\nu_3} = 0,$$

connecting F_1, F_2, F_3. In the particular case of the ikosahedron we have—

$$F_1 \equiv z_1^{30} + z_2^{30} + 522(z_1^{25}z_2^5 - z_1^5 z_2^{25}) - 10005(z_1^{20}z_2^{10} + z_1^{10}z_2^{20});$$

$$F_2 \equiv -(z_1^{20} + z_2^{20}) + 228(z_1^{15}z_2^5 - z_1^5 z_2^{15}) - 494 z_1^{10}z_2^{10};$$

$$F_3 \equiv z_1 z_2(z_1^{10} + 11 z_1^5 z_2^5 - z_2^{10});$$

and $F_1^2 + F_2^3 - 1728 F_3^5 \equiv 0$.

The non-homogeneous function Z is next discussed. It is shown that any form of Z, whatever, is a linear rational function, $(\alpha Z' + \beta)/(\gamma Z' + \delta)$ say, of any particular form Z^1; so that it is sufficient to determine a special form Z subject to the conditions that Z assumes the values $1, 0, \infty$, for the ν_1, ν_2, ν_3 summits respectively. It is found that $Z = cF_2^{\nu_2}/F_3^{\nu_3}$, and thus the synthesis of the polyhedral functions is completed.

In Chapters III. and IV. of his first part, Klein discusses the inversion of the polyhedral functions. If, in the polyhedral equation $cF_2^{\nu_2}/F_3^{\nu_3} = Z$, we suppose Z given and z required, z appears as an N-valued function of Z, whose properties it becomes our business to discuss. Parallel to this problem we have a "form-problem." There are for each of the five polyhedra a set of three forms which are *absolutely* invariant for the 2N homogeneous polyhedral substitutions; thus, for the ikosahedron, these are the special forms F_1, F_2, F_3, themselves. We may then suppose the values of these absolutely invariant forms given, subject to the identical relation which in all cases connects them; and require the values of Z_1 and Z_2. There are in each case 2N solutions of this "form-problem," and it is shown that these can all be obtained from the N solutions of the corresponding polyhedral equation by adjoining an accessory square root. It is, of course, obvious that the N solutions of the polyhedral equation and the 2N solutions of the corresponding form-problem can all be derived from any one of them by the N non-homogeneous and the 2N homogeneous polyhedral substitutions respectively.

A brief graphical discussion is given of the functions Z, Z_1, Z_2; and it is shown that Z satisfies the differential equation—

$$\frac{Z'''}{Z'} - \frac{3}{2}\left(\frac{Z''}{Z'}\right)^2 = \frac{\nu_1^2 - 1}{2\nu_1^2(Z-1)^2} + \frac{\nu_2^2 - 1}{2\nu_2^2 Z^2} + \frac{1/\nu_1^2 + 1/\nu_2^2 - 1/\nu_3^2 - 1}{2(Z-1)Z} \quad \ldots \text{(A)}$$

the left-hand side of which is the differential invariant which Cayley has called the Schwarzian derivative of z with respect to Z (see Forsyth's "Differential Equations," § 61 and chapter vi.); and that Z_1 and Z_2 each satisfy the linear differential equation—

$$y'' + \frac{y'}{Z} + \frac{y'}{4(Z-1)^2 Z^2}\left\{-\frac{1}{\nu_2^2} + Z\left(\frac{1}{\nu_2^2} + \frac{1}{\nu_3^2} - \frac{1}{\nu_1^2} + 1\right) - \frac{Z^2}{\nu_3^2}\right\} = 0.$$

Through the latter equations z_1 and z_2 are identified as particular cases of the Riemannian P-function, and thus connected with the theory of the hypergeometric series. Here Klein's work comes in contact with the well-known researches of Schwarz—"Ueber diejenigen Fälle, in welchen die Gaussische Hypergeometrische Reihe eine Algebraische Function ihres vierten Elementes darstellt" (*Crelle*, Bd. 75).

The inversion of the polyhedral functions is next considered from the standpoint of Galois's theory of the resolution of an algebraical equation. An attractive outline of this theory is given, so far as it concerns the problem on hand. The starting-point may be said to be the famous theorem of Lagrange, which, in a generalized form, runs as follows: If R, R_1, R_2, ... be rational functions of the variables $x_1, x_2, \ldots x_n$, and if R remain unchanged by all the substitutions of the x's which leave $R_1, R_2, \ldots$ simultaneously unaltered, then R can be expressed as a rational function of $R_1, R_2, \ldots$ and of the elementary symmetric functions of the x's. In particular, if we characterize all the functions which admit (*i.e.* are unaltered by) a given group of substitutions, G, as belonging to the family G, we see that all the functions of any family are rationally expressible in terms of one another.

Suppose now that we have any algebraical equations, $f(x) = 0$, whose roots are $x_1, x_2, \ldots x_n$, and we "adjoin" thereto a group of asymmetric functions, $K_1, K_2, \ldots$, of its roots, whose values along with the coefficients of $f(x)$ are supposed to be "known," then there exists a group of substitutions, G, that, viz., for which K_1, $K_2, \ldots$ are unaltered, such that all functions of the family G and no others are rationally expressible in terms of the "known quantities." If R be a function of $x_1, x_2, \ldots x_n$, not belonging to the family, but say to the family g where g is a sub-group in G of the order $\nu = N/n^1$, then we can form an equation for R, viz.,

$$(R - R_1)(R - R_2) \ldots (R - R_{n^1}) = 0,$$

whose coefficients are rational functions of the known quantities. Such an equation is called a resolvent of $f(x) = 0$. All the resolvents constructed by means of functions R which belong to the same family g_1 are identical in the sense that they are rationally transformable into each other, and with these are also identical all resolvents arising from functions belonging to the families $g_2, g_3, \ldots$, where $g_2, g_3, \ldots$ are the sub-groups "associated with g_1" in the main group G of the original equation. There are therefore as many different kinds of resolvents, as there are different sets of associated sub-groups in G. The group Γ of every resolvent is isomorphous with the original group G; that is to say, we can order the two groups so that to every substitution S in G corresponds one S^1 in Γ, and to every combination of substitutions STU .... in G corresponds $S^1T^1U^1$ .... in Γ. If this correspondence be holohedric (one S for every S^1), then the resolvent and the original equation are equivalent in the sense that every root of the one is rationally expressible in terms of the roots of the other and of the known quantities; each is in fact a resolvent of the other. Pre-eminent among this species of resolvents stands the Galois resolvent, whose R is a perfectly asymmetric function as regards the substitutions G. The degree of this resolvent is the highest possible, viz. N. Since the sub-group g_1 belonging to any root R_1 of this equation reduces to the identical substitution, it follows that we can express each of the x's in terms of R_1. In fact, all the roots of the Galois resolvent are rational functions of any one of them; and it has the remarkable property of being transformable into itself by a group of N rational transformations, which stands in holohedric isomorphism with the group Γ. It is also established that an irreducible equation of the Nth degree which is transformable into itself by a group of N rational transformations is its own Galois resolvent; and its group is holohedrically isomorphous with the group of the N transformations. We are now enabled to perceive a very important property of the polyhedral equations, viz. each of them is its own Galois resolvent; the N rational transformations in question being simply the N linear polyhedral transformations. Every polyhedral equation therefore stands in a fundamentally simple relation to any equation of which it can be shown to be a resolvent.

If we consider the case where the isomorphism of the groups G and Γ is not holohedric—that is, where to each of the S^1's corresponds a group of the S's, we see that this necessitates the existence of a self-conjugate (*sibi*-associate) group γ in G to which belong the whole of the R's. If to the other known quantities we now adjoin the R's, the solution of the original equation $f(x) = 0$ will be simplified, because its group is now γ, which is smaller than G. Moreover, the R's themselves are calculable in terms of the known quantities by means of an equation whose group Γ is also smaller than G. In this case, therefore, an essential simplification in the formal solution of the equation $f(x) = 0$ can be effected. If the group γ be either intransitive or composite, a further simplification would ensue, in the one case by the "reduction" of $f(x) = 0$, in the other by the construction of another resolvent having a smaller group than γ.

The application of the latter part of the general theory in combination with the data regarding the groups of the polyhedral substitutions obtained in the earlier chapters, leads at once to important conclusions regarding the polyhedral equations. It is found that the octahedral equation can be solved by extracting in succession a square root, a cube root, and finally two square roots; the tetrahedral equation by the same series of operations, if we omit the first, and the dihedral equation by extracting a square root and then an nth root. All these equations are therefore soluble by means of the ordinary *elementary* algebraical irrationalities.

The ikosahedral equation stands by itself because the ikosahedral substitutions form a "simple" group; its lowest resolvents correspond to the five associate tetrahedral and the six associate dihedral sub-groups of the ikosahedral main group, and are of the fifth and sixth degrees respectively. This is, from one point of view, the main part of the theory, for it leads us to see that the solution of the ikosahedral equation involves an irrationality which exists independently of the ordinary algebraical irrationalities.

Since Abel demonstrated the impossibility of solving general equations whose degree exceeds the fourth by means of elementary algebraical irrationalities, two, or perhaps we should say three, great classes of problems in the higher theory of equations have arisen: (1) to characterize and classify all those exceptional cases of equations of a degree exceeding the fourth which can be solved by elementary irrational operations; (2) to circumscribe the domain of the higher algebraic irrationalities—that is, to characterize and exhaustively classify all the essentially distinct irrational operations which are required for the solution of any algebraical equation of finite order,—this is not to be confounded with the interesting and practically important, but perfectly distinct, question regarding the solution of such equations by means of transcendental irrationalities, such as circular and elliptic functions; (3) in connection with each distinct higher irrationality, there arises, of course, the question as to the characteristics of the various equations which can be solved by means of this irrationality and others of a lower order.

Much has been done in the working out of the first problem by Abel, Kronecker, and others; but comparatively little progress has been made with the second class of problems. In Klein's work we have an important contribution to this new branch of the theory of equations; and a sketch of a general method which seems to promise farther advance in the immediate future. The latter part of the book under review is almost entirely occupied with this subject. He there shows by two different methods that the solution of the general quintic equation can be effected by means of the ikosahedral irrationality combined with an accessory square root. A brief sketch of his first method will enable the reader to understand the general march of the investigation. If to the rational coefficients of the quintic equation we adjoin the square root of its discriminant, its Galois group becomes the 60 even permutations of its roots. Now this is isomorphous with the group of the ikosahedral equation, and therefore (since that group is simple) with the group of any of its resolvents. But it is shown that one of the ikosahedral resolvents ("the principal resolvent") is an equation of the fifth degree of the form $y^5 + 5Qy^3 + 5Ry + S$, where Q, R, S are rational functions of three arbitrary parameters m, n, Z. The question then naturally arises, Can we rationally connect the roots of this resolvent with the roots of the general quintic by properly determining the parameters m, n, Z? By means of a Tchirnhausian transformation, we can reduce the general quintic to a "principal equation" of the form $y^5 + 5\alpha y^2 + 5\beta y + \gamma = 0$; and it is shown that the necessary operations become rational after the adjunction of the square root of the discriminant of the quintic. We have thus two equations, each involving three arbitrary parameters; and it is shown that the determination of m, n, Z in terms of α, β, γ so as to satisfy the equations $Q = \alpha$, $R = \beta$, $S = \gamma$ involve no farther irrational operations. The calculations in both methods are full of beautiful details, partly geometrical and partly analytical in character.

In the last chapter of the first part a general survey of the theory of the polyhedral functions is given, wherein their relation to a variety of other functions is pointed out. In particular it is shown that the polyhedral functions virtually embrace all functions that "admit" a *finite* group of linear transformations. The proof of this depends essentially on the fact that the diophantine equation, $\Sigma(1 - 1/\nu_i) = 2 - 2/N$, where the ν_i's and N are all finite and positive, has only four solutions, viz. the values of ν_1, ν_2, ν_3, N (given in the above table), which characterize the polyhedral functions. In these four cases $1/\nu_1 + 1/\nu_2 + 1/\nu_3 > 1$. If in the differential equation (A) we give to ν_1, ν_2, ν_3 other integral values for which $1/\nu_1 + 1/\nu_2 + 1/\nu_3 =$ or < 1, we get the Schwarzian functions, which are transcendents admitting infinite groups of linear substitutions. Among these, as a limiting case corresponding to $\nu_1 = 2$, $\nu_2 = 3$, $\nu_3 = \infty$, are found the elliptic modular functions. This fact naturally leads to the attempt to solve the polyhedral equations by means of transcendentally irrational functions; and it is shown that, just as the binomial equation, $Z^n = A$, can be solved by means of logarithms, and the dihedral equation, $z^n + z^{-n} = -4Z_1 + 2$, by means of circular functions, so the tetrahedral, octahedral, and ikosahedral equations can be solved by means of elliptic modular functions.

The above imperfect sketch of Klein's "Ikosahedron" will, we trust, be held sufficient to justify us in saying that Mr. Morris's hope that his translation "may contribute towards supplying the pressing need of text-books upon the higher branches of mathematic" is not a vain hope. He could not, in our opinion, have made a better beginning. If our critical responsibility compels us to point out some defects in the execution of the work, we trust that this will be understood as indicating our desire to see the book made perfect; and not construed into depreciation of a valuable service to the cause of pure mathematics.

We strongly advise the author to have the translation read by some one who is familiar with both English and German idioms, and who possesses also some familiarity with the departments of mathematics concerned. In proof of the necessity for such a revision, we draw the author's attention to the following points, which are merely a few of those that have attracted our attention. When Klein says (Pt. I. chap. iii., § 7), "Die Lineare Differentialgleichung zweiter Ordnung, verlangt also, . . ., zu ihrer Lösung nur noch eine einzige Quadratur;" he does *not* mean, "The linear differential equation of the second order, therefore, requires, . . . , only a single *square root* besides in order to solve it." *Quadratur* means simply *quadrature* (*i.e.*, direct integration), it never means *square root*. Here a knowledge of the properties of the Schwarzian derivative might have helped the translator to divine the meaning of the German technical term. On p. 96, "But *for this* the determination of the R's themselves is more easy to carry out," is not a good, but in fact a misleading translation of the German "Dafür aber ist die Bestimmung . . ." *Dafür* here means "in compensation for this." At the foot of the same page occurs a very common confusion between *wenn eben* and *wenn gleich*, which has the effect of exactly reversing the meaning of the note. "Hierdurch kann $f(x) = 0$ (wenn eben γ, in den x geschrieben, nicht transitive ist) möglicherweise reducibel geworden sein," means, "Hereby $f(x) = 0$ may possibly have become reducible (namely if (or precisely if) γ, when expressed in terms of the x's, is intransitive)" for, of course, an equation is reducible if, and not unless, its group be intransitive. A still more important error occurs on the following page, where, in the definition of the Galois resolvent, "ihre einzelne Wurzel bei jeder in G enthaltenen Vertauschung der x umgeändert wird" is translated "its individual roots are *unaltered*, &c." First of all, this makes nonsense of the definition, as definite knowledge of the subject would have shown; and farther, supposing the translator to have read *un-* by mistake for *um-*, a knowledge of German idiom would have shown him that "ungeändert *wird*" makes nonsense of the German. The error is deliberately repeated on the following page, where "in umgeänderter Reihenfolge" is translated in "unaltered sequence," instead of "in altered sequence." These are vital errors, which should at once be corrected by means of an "errata-slip"; for they would be a serious rock of offence for a tyro in reading the passages where they occur. There are many other cases, however, where loose translation somewhat obscures the crisp and lucid exposition of Klein, which is a pity, for this quality is not all too common among Klein's countrymen. There are a considerable number of misprints, many of them copied from the original. An amusing instance of this occurs in the first footnote on p. 73, where the title of Schwarz's well-known memoir begins "Ueber *dienigen* Fälle, &c."; this is in the original, but the transcriber should have known that *dienigen* is impossible German. Nevertheless, we declare, with all the sanction of our critical stool of infallibility, that Mr. Morris's translation is a notable piece of good work; and he did well to publish it without waiting to perfect his knowledge of German idiom or of Galois's theory. The blemishes alluded to can be easily amended when another edition is called for, which will be speedily, if our good wishes avail.

G. CH.

THE NORTHFLEET SERIES ELECTRIC TRAMWAY.

On Monday, April 29, there was opened for regular passenger traffic an electric tramway at Northfleet, near Gravesend, which marks an era in the history of electric traction. This line has been run experimentally for the last month, but the seven years Board of Trade certificate having been received, this line now enters on the commercial stage of its existence. Four tramways on which electricity is the motive power have been in regular use for the last few years in Great Britain: it is not, therefore, because the Northfleet line is the first electric tramway in this country that it has attracted considerable attention; nor is it because it is the longest electric tramway, for two of the other four are of much greater length; but it is because this Northfleet line has been constructed on a totally different principle from that hitherto adopted on this side of the Atlantic that it is worthy of special consideration.

When a number of electric lamps or motors have to be supplied with power from a common centre, there are two well-known methods by which this can be done. They can either be joined "in parallel," as it is technically called, or they can be coupled up "in series." In the parallel system, the one generally adopted with electric lighting, and hitherto the only method that has been employed with the electric tramways in Europe, the electric current that passes through any lamp or motor does not pass through any other, and the dynamo produces a large current equal to the sum of all the currents passing through all the lamps or motors. In proceeding, therefore, from the dynamo end of the circuit to the distant end, there is a steady falling off in the current, but the electric pressure remains, or may remain, nearly constant. In the series system, on the other hand, the whole current produced by the dynamo passes through all the lamps or motors in succession, and therefore this current can be small. The initial electric pressure, on the other hand, must be large, since the energy imparted by the current to each lamp or motor is represented by a drop in the electric pressure. Since the energy furnished by the dynamo depends on the product of the current into the electric pressure it produces, while the waste of power in heating the conductor depends on the square of the current flowing through the conductor, it is clear that while any amount of energy can be supplied by either system, the use of high pressure and small current is by far the more economical as regards the power wasted in heating the conductor, this economy being the greater the greater the number of lamps or motors on the circuit.

Until a few years ago, however, it was not clear how it was possible to run motors electrically in series when the motors were themselves in bodily motion, as they must be when employed to propel tramcars. In 1881, Profs. Ayrton and Perry, for the purpose of diminishing the loss of power through the leakage of the current that occurs from the insulated rail of an electric railway to the earth, and which becomes serious when the line is long, proposed a plan of electrically subdividing the railway track into sections so arranged that the electric current was only supplied to that section of the track on which a train happened to be at any moment. This system was described and shown in action at a lecture given by one of the inventors at the Royal Institution in 1882, and the late Prof. Fleeming Jenkin, on reading the account of this lecture, saw that the device of employing an electrically subdivided conductor supplied the means of running electrical trains *in series*. A combination was, therefore, brought about between these three Professors to develop electric traction. This combination resulted in the formation of the Telpherage Syndicate, and lastly in the Series Electrical Traction Syndicate, to whom is due the construction of the first series line in Europe, the one that was opened for public traffic at Northfleet, on April 29.

The track itself does not at first sight appear to differ from an ordinary horse tramway track, there being no overhead wires as in the American electric tramways, nor auxiliary raised insulated rail, as at Portrush, nor central trough, as at Blackpool. A closer inspection, however, shows that one of the rails at Northfleet, instead of being simply grooved, is a double rail with a cavity or slot between the two portions. Fig. 1 shows the general cross-section of the line, the upper portion only of which is of course visible to the passer-by. In the cavity "the arrow," as it is called, glides, being drawn along by the moving car, the function of the arrow being to open the electrical

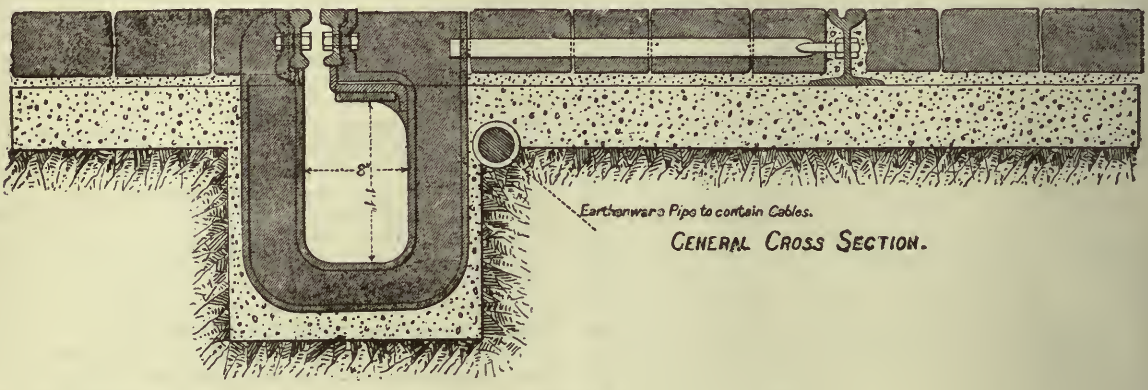


Fig. 1.

conductor at successive points, and insert the electric motor carried by the moving car in the electrical circuit. This arrow is made of flexible leather with a kind of steel spear-head at each end; it is coated with two flexible conducting strips, 1, 2 (Fig. 2), insulated from one another, and permanently connected respectively with the two terminals of the motor. As this arrow glides along, it passes, as seen in Fig. 3, between the two portions of each spring-jack, the spring-jack being shown in detail in Fig. 4. The arrow keeps open two spring-jacks at any one time, the portion of the cable joining them being either cut out of circuit or short-circuited, its place in the electric circuit being temporarily occupied by the motor on the car. This result is attained by the con-

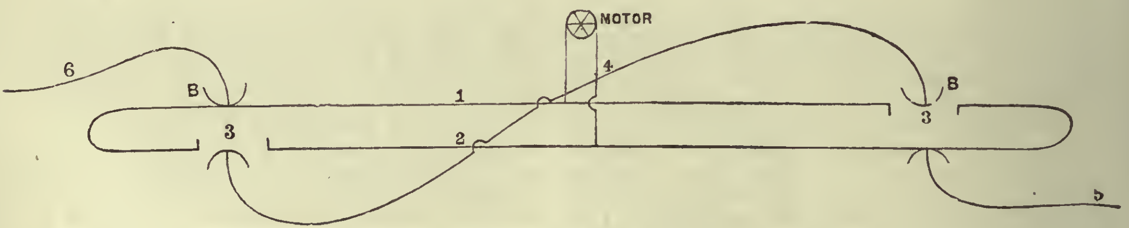


Fig. 2.—The Arrow.

ducting-strips 1, 2 (Fig. 2) on the arrow, being each wrapped round one end, and by an insulated space, 3, 3, being left on each side, slightly longer than the surface of contact B of the spring-jack. When the sceptical Englishman, who, in the past, could not realize that railways could ever succeed if the carriages were not shaped and painted like mail-coaches, reads a description of the Northfleet series tramway, he at once jumps to the conclusion that stones must necessarily get wedged in the slot; that the cavity will get filled up with mud; that the arrow must stick; and that the method is impossible in practice, though very pretty in theory. When he is told that a *series* electric tramway has been running successfully for some time in Denver, Colorado, and that

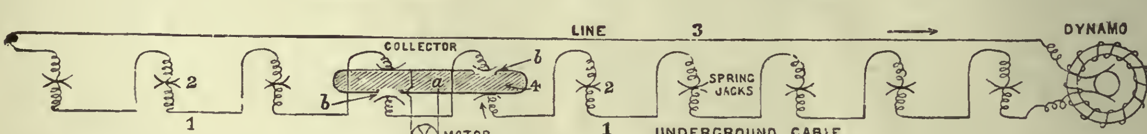


Fig. 3.—Diagrammatical Illustration of Series Line.

another *series* line, twelve miles long, with forty cars on it, is completed, or on the verge of completion, in Columbus, Ohio, he merely shrugs his shoulders and implies that such crude ideas may do for America, but that in this country we want time-honoured well-tried methods, and not new-fangled notions. The Northfleet cars, however, seem to have a marked disregard for conservative prejudices, since the arrow, with an ease and lofty contempt that makes one respect the silent power of the electric current, simply whisks out of its way any stone that has been intentionally jammed into the slot as tightly as any mischievous London urchin can fix it.

The spring-jack (Fig. 4) consists of a pair of glazed earthenware blocks, 14 × 3 × 4 inches. To each block is attached, by means of a double spiral spring, a gun-metal casting, curved at its ends to allow of the easy entrance of the arrow. The spring-jacks are arranged so that they can be taken out or replaced in the conduit in a few minutes in case of any failure. The electric resistance that they offer is much smaller than would have been anticipated, the total measured resistance of the entire line being but little higher than the calculated resistance of the insulated cable. This is probably due to the surfaces of the spring-jacks being kept bright and clean by the arrow constantly running through them.

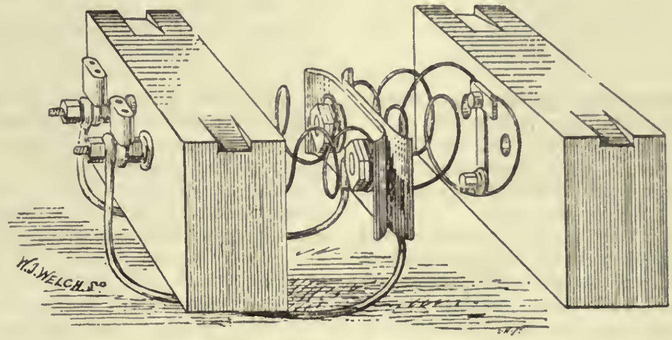


FIG. 4.—The Spring Jack.

In order that the speed of any one car shall not be affected by the starting or stopping of any other, it is necessary, with series working, that a *constant current* should be supplied to the circuit. Now while it is possible, by winding the field-magnets of a dynamo in a particular way, known as "compounding," to cause it, when running at a fixed speed, to supply perfectly constant pressure to a circuit, no matter how the resistance of the circuit may vary, no such solution has yet been practically attained when the supply conditions are *constant current*. Hence some mechanical device is necessary in the latter case, and the one employed with the Northfleet dynamo is that due to Messrs. Statter, and

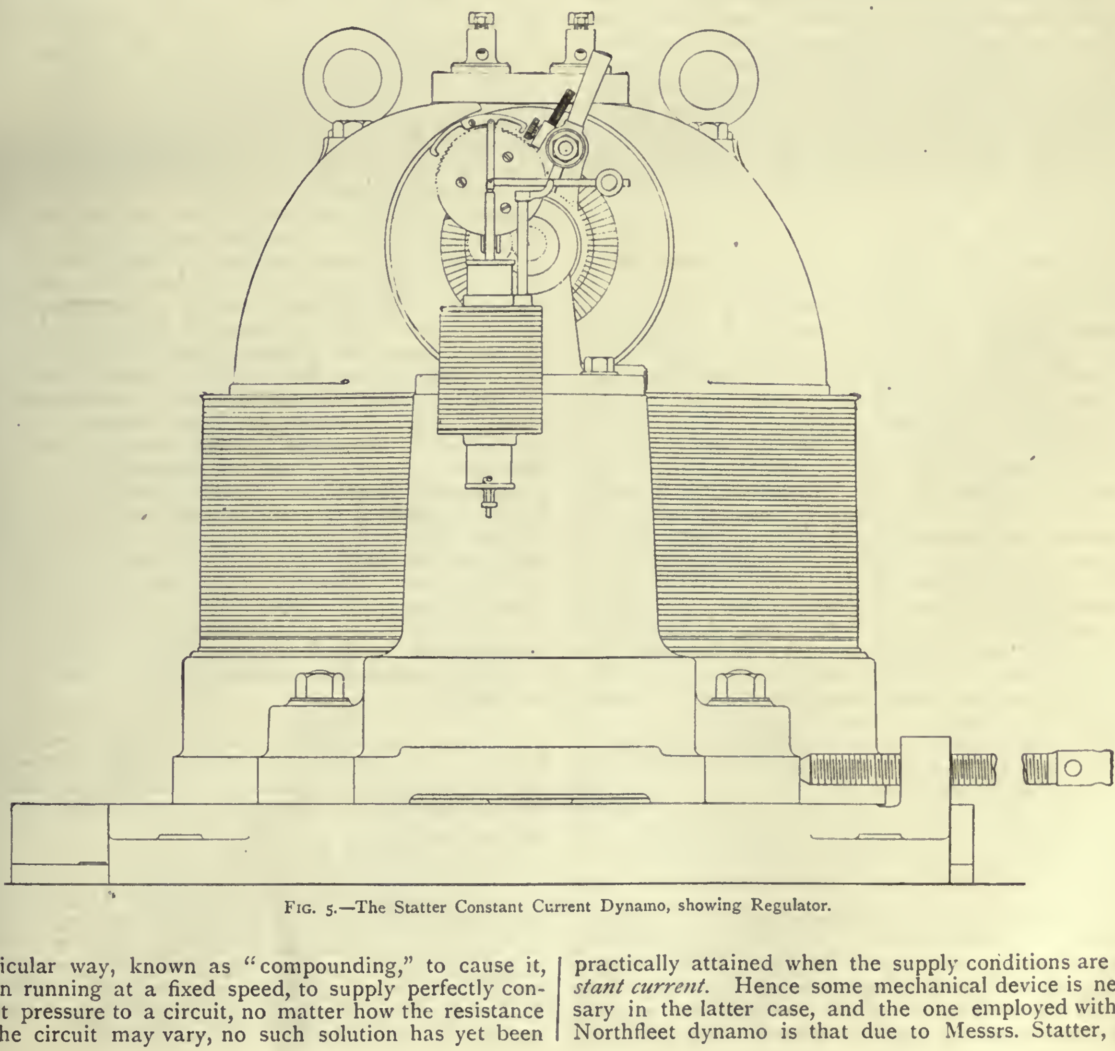


FIG. 5.—The Statter Constant Current Dynamo, showing Regulator.

seen in Fig. 5. A small pinion rotated by the dynamo shaft rocks a double ratchet by means of an eccentric. One or other of the ends of this ratchet is pulled down and made to engage with the ratchet wheel depending on whether the current is greater or less than 50 amperes, the normal current supplied to the line. The rotation of the ratchet wheel alters the positions of the brushes on the commutator, until the current is diminished or increased to 50 amperes, when the iron core attached to the ratchet, and which was previously sucked down below its normal position by the solenoid, or not sucked down so far, is now held in its normal position, and the ratchet kept free of the ratchet wheel. This mechanical constant current regulator works well, with a surprisingly small amount of sparking at the commutator.

As constant current is supplied to the line, the speed of the car could not be altered by introducing resistance into the circuit; what is done therefore is to shunt the field magnets of the motor with a less and less resistance by moving a lever on the car, as less and less power is required to be developed by the motor. When the car is at rest at the end of the journey, the motor is entirely cut out of the circuit by the handle being pushed full home. With horse tramcars a mechanical brake must be employed, and the energy of the moving car wasted in friction; indeed with the continuous vacuum brakes on the modern railway trains, not merely is the energy of the train wasted, but coal is actually burnt to stop the train. Some years ago, however, Profs. Ayrton and Perry pointed out that when an electric train was running down hill, or when it was desired to stop the train, there was no necessity to apply a mechanical brake and waste the energy of the moving train in friction, because by turning a handle the electromotor could be converted into a dynamo, and the train could be slowed or stopped by its energy being given up to all the other trains running on the same railway, so that trains going down hill could help the trains going up hill, and the stopping trains could help the starting trains. And at that time they proposed detailed methods for carrying out this economical mutual aid arrangement whether the trains were running in parallel or in series. But there is this great difference between the two systems, that whereas with motors in parallel it is only as long as a stopping train is still running fairly fast that it can help other trains; on the other hand, when one of a group of motors in series has been temporarily converted into a dynamo by the reversal of the connection of its field-magnets, this motor can return energy to the system down to the very last rotation of its armature. This difference, which is greatly to the advantage of the series system, will be easily understood if it be remembered that a motor will help other motors in series with it if it supplies a forward electromotive force, however small, whereas if the motors be in parallel it is necessary, in order that a motor should give energy to the system, that it should be able to reverse the direction of the current that was previously passing through it—in other words, produce an electromotive force actually larger than the potential difference set up between the mains by the dynamo itself.

And not only is this form of brake very economical in that it acts by saving power instead of by wasting it, but in addition its application imposes no tax on the driver's strength, as is the case with mechanical brakes where the pressure of the brake blocks is actually exerted by the driver's hand or foot—a consideration of considerable importance in these days of the natural revolt of the "tram slave."

At each end of the Northfleet cars there are two handles, one of which regulates the resistance shunting the field-magnet of the motor, and which therefore replaces the handle working the throttle valve of a steam locomotive, while the other handle reverses the terminals of the field-magnet, or short-circuits them when it is in its middle position, and therefore replaces the handle which operates the link motion in the locomotive. During the several journeys we made in the cars, we had frequent opportunity of seeing how perfectly they were under control, even when descending the steep hill near the Northfleet railway station.

One defect of the parallel system of working electric tram-lines is that it is possible for a mischievous person to cut off the power from the whole line, while at the same time the constant potential difference dynamo is made to produce far more than its normal current, by his laying an iron crowbar so as to electrically connect the going and return conductor. This result he may be able to accomplish without much difficulty, since both these conductors must be sufficiently exposed along their whole length that the passing train can maintain electrical contact with both of them. With the series system, on the other hand, such a catastrophe is impossible, since the return conductor, 3, marked "line" in Fig. 3, is completely buried out of sight.

A considerable amount of ingenuity has been displayed in the mechanical details both on the cars themselves and on the track at Northfleet. The motor, for example, is geared directly to a spur wheel on the car wheel shaft by double helical gearing, which runs without biting, and at the same time without any chance of slip, since the axle of the motor and the axle of the car wheel driven by it are always maintained at exactly the same distance apart. The result is attained by supporting one end of the motor framework from two bearings on the axle of the car wheel, and the other end by stout springs from the car itself. The tram-line is for the greater portion a single track, hence several places where the up and down cars can pass, "turn-outs" as they are technically called, have been provided. As both the up and down lines at the turn-outs are electrically in series, special electrical devices which appear to work very well have been provided for the facing points at the two ends of each turn-out. At one portion of the line the road is so narrow that it would have been very inconvenient to the ordinary horse traffic, had an up and a down tramcar gone along the same side of the road. An up car has therefore to pass the horse traffic by following the "near side," so also has a down car—in other words, the electric tramcar if it be going in one direction has to be on the opposite side of the road from that followed by an electric tramcar when going in the contrary direction. But as the road is too narrow for two sets of rails the track here consists of three rails, A B and C, A and B being used by the car when going in one direction, and C and B when it is returning; the facing points at the ends of this section being fitted with special mechanical and electrical devices, which also appear to accomplish their aims with perfect satisfaction.

A portion of the line has a long steep gradient of 1 in 32, but instead of jaded horses having to tug the cars up this hill, they ascend it at a rate of about nine miles an hour, so that the whole journey, which is a little under one mile, is accomplished when desired in three minutes and a half.

It is but a few weeks ago that the first trial trip of the Northfleet line was made; it is but now that it is opened for public use; and yet already the passers-by and the shopkeepers along the route have ceased to wonder how it is that horseless cars full of people rush up hill without smoke, quickly start in either direction, and as quickly stop when directed by the passengers to do so. After the Englishman has been spending some time conclusively proving to himself that a *series* tram-line was a practical impossibility, while the American was engaged in carrying out the trite saying that "the best way to do a thing is just to go and do it," our countrymen now accept the regular daily running of the *series* tram-line at Northfleet as a matter of course, and have forgotten that its very marked success ought to astonish them.

THE EXAMINATIONS FOR WOOLWICH AND SANDHURST.

THE revised Code for these examinations has at length been published. It is to come into force after January 1, 1891. There is to be a preliminary examination in elementary Arithmetic, Euclid, Algebra, French or German, writing English from dictation, elementary Latin, Geometrical Drawing, and Geography, for which no marks are given. We regret that as this examination has now been extended till it includes nearly all the main subjects of a modern education, an elementary knowledge of some branch of science is not also required. There is also to be a further examination for those who pass the preliminary, for which the following Code has been adopted:—

Class I.—*Obligatory.*

Mathematics (for Woolwich) ...	3000 Marks
,, (for Sandhurst) ...	2500 ,,
Latin	2000 ,,
French or German	2000 ,,

Class II.—*Any two Subjects may be taken up.*

Higher Mathematics	2000 Marks
German or French	2000 ,,
Greek	2000 ,,
English History	2000 ,,
Chemistry	2000 ,,
Physics	2000 ,,
Physical Geography and Geology	2000 ,,

Class III.—*All may be taken.*

English Composition	500 Marks
Freehand Drawing	500 ,,
Geometrical Drawing	1000 ,,

Notwithstanding the relative positions of science and Latin—which seem indefensible in regard to the Woolwich Cadets—this Code of marks is decidedly better than that which was the subject of so much adverse criticism in the early months of last year. In the first place, the allotment of marks which had such disastrous effects when adopted a few years ago in the Sandhurst competitions is at length abandoned, and candidates will no longer be at any disadvantage in this respect if they offer themselves for examination in such subjects as science, history, or Greek.

In the second place, it will now be possible for candidates to offer Greek or history, together with a branch of science, or to offer both chemistry and physics. In the case of some candidates this may prove a considerable advantage; though the fact that the obligatory and advanced mathematics can to some extent be studied concurrently may probably induce a large proportion to select the latter from Class II.

Thirdly, the better position that was claimed for experimental sciences in the Woolwich competition has now also been given to these subjects in the Sandhurst examination.

At first sight it may appear, after all that has been said and done, that the position of the experimental sciences as members of Class II. is not very splendid. It is therefore worth while to point out, lest it should be overlooked by teachers, that chemistry and physics are so important in the curriculum at the Royal Military Academy, that it will be greatly to the advantage of candidates for the scientific branches to study and offer one of these subjects, now their prospects of success will no longer be diminished by doing so. Hence, as a whole, the scheme for selecting and educating cadets for the Engineers and Artillery is now reasonably favourable for those who exhibit an aptitude for the experimental branches of science. We think this will soon be recognized by the candidates themselves, and that those who are interested in the science of our public schools will also quickly perceive the importance of the changes that have been secured in the face of very considerable difficulties by the action of Sir Henry Roscoe and the other scientific members of the House of Commons.

Altogether, therefore, it may decidedly be said that the authorities at the War Office are to be congratulated on the result of their consultations with Sir Henry Roscoe and other educational authorities. The new Code is not ideal. It does not fully recognize the importance of natural science in modern education, and it is to be feared that it will lengthen the examination to some extent. But, if it be fairly carried out, scientific candidates will not in future be placed at any great disadvantage, as compared with those who have studied other subjects, in the examinations for admission to either branch of the Army. In regard to this last point, however, it would be well if the Civil Service Commission took steps to remove the blot in their system of conducting public competitive examinations to which attention was called, some years ago, by Sir Lyon Playfair, in his Presidential Address to the British Association. We allude to the irregularity with which marks are awarded for the various subjects at more than one of these examinations. These irregularities are still unduly large. We have before us an account of the marks given in six examinations for Woolwich, taken at random during the years 1884–88, and it appears that, at these examinations, successful candidates who have offered French, German, Greek, and experimental science have been given, on an average, 38, 35, 29, and 28 per cent. of the allotted maximum marks. A successful candidate offering Greek and science would, on an average, have obtained 1154 out of the maximum of 2000; whilst one offering French and German would have been given 1491 out of the same maximum. A similar tale is told by the highest marks awarded in the respective subjects. It will scarcely be contended that, on the whole, the superior teaching of modern languages, as compared with that of Greek and science, justifies this. It is perhaps too much to hope for absolutely equal rates of marking, as between different subjects at each separate examination. But we do not think that during such considerable periods of time the variations should be so great as they have been, especially in the case of subjects taken up by fairly large proportions of the candidates. Such variations do real harm by encouraging the mark-hunter, who is ever on the alert, and by artificially stimulating the favoured subjects at the expense of others of importance.

We understand that the examiners are not to be blamed for this state of things, but rather that the Civil Service Commissioners are directly responsible. For it is stated by Mr. Oscar Browning, in the *Journal of Education* for April, that the examiners "receive a paper as a model which they are told to copy as exactly as possible. They are informed of the average of marks given at the last examination, and they are enjoined to adhere to the standard with special care." If this goes on year after year, as seems to be implied, it is difficult to see how any code of marks can secure a fair examination. If the candidates who offered any subject were hardly treated in 1888, the chances are that those who offer the same subject in 1889 will also suffer hardness. For if the candidates in that subject be better in 1889 than they were in 1888 they will be relatively still more hardly treated. If of similar calibre they will be treated equally badly. Only if they happen to be inferior will they stand at an advantage.

If the system of examining be as it is represented, it is high time that it should be revised by those who are responsible for it.

NOTES.

We regret to announce the death of Mr. Robert Damon, of Weymouth, the well-known naturalist and geologist. He died suddenly on Saturday, the 4th instant, from heart disease. Mr. Damon was the author of an excellent work on the "Geology of Weymouth and the Isle of Portland," now in its second edition. He was a most extensive traveller and an assiduous collector. He obtained a marvellous series of fossil fishes from the Cretaceous beds of the Lebanon, Syria, now in the British Natural History Museum, also the most complete skeleton of that rare and extinct Sirenian, "Steller's Sea-cow," from Behring Island. Although in his seventy-fifth year, he contemplated another trip to Siberia to procure an entire Mammoth's skeleton for the National Museum. Only a few years ago he took passage from Nijni Novgorod, down the Volga to Astrakhan, for the purpose of collecting a complete series of the fishes of the Caspian Sea, in which he was most successful. He lately purchased the celebrated zoological collections forming the "Godeffroy Museum" in Hamburg, and he had perhaps the largest collection of recent shells in this country. Mr. Damon's loss will be long felt by a wide circle of scientific friends in all parts of the world, by whom he was warmly esteemed and respected.

The Paris Exhibition was opened on Monday by the President of the French Republic. As usual on such occasions, there was a great display of empty spaces which ought to have been, and soon will be, filled with exhibits. The British Section was greatly in advance of the others. M. Carnot, in speaking of the general character of the Exhibition, referred emphatically to "the surprises reserved for our generation by the marvellous progress of science."

At the Royal Academy banquet, on Saturday last, Sir Henry Roscoe responded to the toast for "Science." He spoke of the intimate relations between science and art, and, as an illustration of the services rendered by the former to the latter, referred to the fact that this year we celebrate the jubilee of the discovery of photography. "In 1839," he said, "the power of the sun to draw in black and white was first indicated by Daguerre and Fox Talbot. In her infancy exhibiting but slight promise of artistic life, Photography, in her maturity, has developed true artistic power, so that she has now grown to be a trusted and valued helpmate to the artist, while she can produce effects and catch expressions which might defy the brush of a Turner or a Reynolds."

An International Congress of Photography will be held in Paris from August 6 to 17. If we may judge from the programme, which has been issued by the Organizing Committee, the proceedings are likely to be of great interest. Anyone may suggest subjects of discussion on condition that the suggestions are sent to the secretary (M. S. Pector, 9 rue Lincoln, Paris) at least fifteen days before the opening of the Congress. On August 20 there will be a public conference on the labours of the Congress.

The third of the series of One-Man Photographic Exhibitions at the Camera Club is now open to visitors on presentation of card. The Exhibition will continue for about two months. The object of this series of exhibitions is to bring together, in turn, representative collections of the work of the best photographic artists. The photographs shown on the present occasion are by Mr. J. Gale. They are chiefly photographs of landscape, and landscape with figure, and are printed in platinum and in silver processes.

Science gives the following as a complete list of the papers presented and read to the American National Academy of Science, at its meeting in April: on composite coronagraphy, by D. P. Todd; additional experimental proof that the relative coefficient of expansion between Baily's metal and steel is constant between the limits zero and 95° F. (read by title), by W. A. Rogers; notice on the method and results of a systematic study of the action of definitely related chemical compounds upon animals, by Wolcott Gibbs and Hobart Hare; on sensations of colour, and determinations of gravity, by C. S. Peirce; on the Pliocene Vertebrate fauna of Western North America, and on the North American *Proboscidea*, by E. D. Cope; on the mass of Saturn, by A. Hall, Jun.; on the nature and composition of double halides (read by title); on the rate of reduction of nitro-compounds, and on some connection between taste and chemical composition, by Ira Remsen; recent researches in atmospheric electricity, by T. C. Mendenhall; measurement by light-waves, by A. A. Michelson; on the feasibility of the establishment of a light-wave as the ultimate standard of length, by A. A. Michelson and E. W. Morley; on the general laws pertaining to stellar variation, by S. C. Chandler; review of the trivial names in Piazzi's Star Catalogue, by C. H. F. Peters; on Cretaceous flora of North America, by J. S. Newberry; terrestrial magnetism (read by title), Cleveland Abbe; spectrum photography in the ultra-violet, by Romyn Hitchcock; North American *Pelagidæ* (read by title), and development of Crustacea (read by title), by W. K. Brooks; the plane of demarcation between the Cambrian and pre-Cambrian rocks, by C. D. Walcott; report of the American Eclipse Expedition to Japan, 1887, by D. P. Todd.

It is reported from India that Mr. Blanford, Meteorological Reporter to the Government of India, who retires at the end of his furlough, has been recommended for the special pension of 6000 rupees per annum.

The following "resolution" of the Government of Bombay, which has just been published, tells its own story, and adds another to the already numerous examples of the well-judged munificence of the Parsee community of Bombay. The resolution is entitled "Scientific Medical Research." "(1) The sum of Rs. 75,000 having been placed at the disposal of his Excellency the Governor by Mr. Framjee Dinshaw Petit, for the purpose of erecting and fitting a laboratory for scientific medical research, on a site which has been approved by the donor, in the immediate vicinity of the Grant Medical College, the Governor in Council has much pleasure in accepting the offer, and, in doing so, desires publicly to thank Mr. Framjee Dinshaw Petit for his munificence in supplying an institution, the want of which has long been felt by those most interested in promoting the cause of higher medical education in this Presidency. (2) The Governor in Council is pleased to direct that the institution shall be called 'The Framjee Dinshaw Petit Laboratory for Scientific Research.' (3) Instructions for the preparation of the necessary plans and estimates for the proposed building have already been given."

The native population of Benares cannot be said to have very advanced ideas as to the importance of sanitary science. The other day a monster meeting was held in that city to protest against certain proposed drainage and water supply schemes, and a petition to the Government condemning the entire action of the municipality in the matter is said to bear 100,000 signatures. According to the Calcutta Correspondent of the *Times*, the petitioners emphatically decline to pay by increased taxation for any new system.

Last winter the Vienna Medical School was attended by 150 British and American medical graduates, among whom were many Edinburgh men. As many medical students, on their arrival at Vienna, do not know German, the Vienna *Weekly News* has opened a special "medical inquiry office" near the hospital, where information as to lectures, lodgings, &c., is given without charge to British and American medical men.

The same journal publishes weekly a list of forthcoming courses of lectures at the Universities of Vienna and Berlin.

THE *Times of Colombo* announces the arrival in Ceylon of two naturalists, Herr Frühstorfer and Herr Kannegieter, the former a German, the latter a native of Amsterdam. Herr Frühstorfer has already travelled over a great part of the world making natural history collections, while his companion is travelling on behalf of the collection of Herr Van de Poll. Both were about to proceed to the southern part of Ceylon, and after a few weeks' exploration they intended going, one to Malacca and Borneo, the other to Sumatra and Java, for scientific purposes.

A SEVERE earthquake lasting four seconds occurred at Agram on April 27 at 8.35 p.m.

A NEW stalactite cave has been found at Hönnethal, in Sauerland, not far from the village of Sanssouci. It is not very large, but has many beautiful stalactites.

COMPLAINTS having, on several occasions, been made to the Fishery Board for Scotland that salmon smolts are exposed for sale and sold, the Board have issued a notice to the effect that such sale, or exposing for sale, is illegal, and renders the seller or exposer liable to severe pecuniary penalties. The word "salmon" in the Salmon Fishery Acts of 1862 and 1868 means and includes "salmon, grilse, sea trout, bull trout, smolts, parr, and other migratory fish of the salmon kind." All offences under the Salmon Fishery Acts of 1862 and 1868 may be prosecuted, and all penalties incurred may be recovered, "before any sheriff or any two or more justices acting together, and having jurisdiction in the place where the offence was committed, at the instance of the clerk of any District Board, or of any other person."

WITH regard to Prof. Harker's article on a new farm pest, printed in NATURE last week, Miss Ormerod writes that, "if, by any accident, readers should think that what her valued friend Prof. Harker meant only as a courteous acknowledgment of specimens was an expression of belief in the injurious powers of this worm, she would in such case like to be able to mention that up to the present time she sees no reason for alarm."

A SERIES of experiments upon combustions in nitric acid vapour have been made by Dr. P. T. Austen, of Rutger's College, U.S. The gaseous nitric acid is most conveniently obtained in the following manner. Into a large flask, whose neck is sufficiently wide to admit a good-sized deflagrating spoon, a quantity of sulphuric acid is poured, so as to form a layer about half an inch deep. About ten to twenty grammes of potassium nitrate, in crystals averaging a quarter of an inch in size, are then added. On careful heating, the air is rapidly expelled, and the flask becomes filled with the clear vapour of nitric acid. A glowing chip of wood held in this vapour inflames and burns energetically, something after the manner of combustion in oxygen; but, as the red tetroxide of nitrogen, N_2O_4, is formed by the reduction of the nitric acid, a ruddy halo is seen to play around the flame. Charcoal, especially bark-charcoal, burns brilliantly, the scintillations in the red tetroxide gas producing an unusually fine effect. In a similar manner a steel watch-spring may be burnt as in oxygen, the combustion being started with a little sulphur; the effect, however, is quite different from that in oxygen, owing to the formation of a red halo around each melted globule of iron as it falls. A layer of sand should be placed in the bottom of the flask in this experiment, in order to prevent fracture. Phosphorus burns with great beauty, the dazzling white flame passing into a deep red at the edges. By far the most beautiful effects, however, are obtained by the combustion of readily oxidizable gases from jets suspended in the nitric acid vapour. Hydrogen burns with an intensely white flame, totally unlike that in oxygen, surrounded by a deep red envelope. Coal gas continues to burn with a white centre, enveloped as in case of hydrogen by a red halo; when first introduced the flame becomes musical, then degenerates into a series of rapid slight explosions; at length, after a certain amount of nitrogen tetroxide has formed, it burns quietly. Sulphuretted hydrogen gas burns with a bright yellow flame, and the flask becomes filled with a cloud of minute chamber-crystals, resulting from the action of the sulphur dioxide and water formed upon the tetroxide of nitrogen simultaneously produced. Ammonia gas burning in nitric acid vapour is perhaps the most beautiful case of simple combustion yet investigated. Success in this experiment appears to depend entirely upon the size of the orifice of the jet, which should not be less than an eighth of an inch in diameter. As soon as the jet, which of course should be turned upwards, from which a good stream of ammonia is issuing, is lowered to a level with the mouth of the flask, it may be readily ignited. On lowering it into the centre of the flask, the flame is seen to consist of a bright yellow nucleus surrounded by a greenish-yellow envelope; this, in turn, passes into an outer envelope of a carmine-red colour, which deepens as the amount of nitrogen tetroxide increases.

ACCORDING to the *Manchester Guardian*, a technical school has lately been added to the ancient Chetham College, "the most unique piece of antiquity" left in Manchester. It seems that a well-known employer of labour in Salford, and a strong supporter of technical education in Manchester and the neighbourhood, generously offered to fit up a workshop and supply it with all necessary tools for the use of Chetham College. The offer, which was regarded both as a very generous and a very happy one, was accepted by the authorities. The result was the erection of a building at the north-east rear of the College dormitories. The building, which is very well lighted and comfortably heated, has been fitted up with lathes (for wood and iron) driven by a steam-engine; also benches, drilling machines, grindstones, blacksmith's forge, vices, &c. The results so far are regarded as highly satisfactory. Some forty-five of the boys are now regularly engaged in the shop; fifteen working in the morning, fifteen in the afternoon, another batch of fifteen the next morning, and so on. Each boy works nine hours in the shop every week.

MR. ROWLAND WARD writes to the *Times* that on Saturday, April 27, one of the keepers on the estate of Mr. Farnal Watson, in Surrey, trapped a fine specimen of the kite (*Falco milvus*)—"a grand bird," says Mr. Ward, "at one time common on our moors before men became so many in the land, and their hospitality, even to such visitors, so scant." Mr. Ward notes that these birds are still sometimes encountered in Wales.

MR. ALLAN HUME proposes to issue a second edition of his "Nests and Eggs of Indian Birds." It will be edited by Mr. E. W. Oates, author of a "Hand-book to the Birds of British Burmah," and will incorporate all the notes which Mr. Hume's numerous correspondents in all parts of India have sent to him since 1873, as well as some notes from other sources. The work will be published in three volumes, 8vo, of 500 pages each; but for the convenience of subscribers it will be issued in six parts, one of which will be completed every three months, beginning from an early date. The publisher will be Mr. R. H. Porter, 18 Princes Street, Cavendish Square, London, W.

A COLLECTION of Prof. Weismann's essays on heredity has been translated under the care of Mr. E. B. Poulton, of Oxford, and will form the second volume of the series of translations of foreign biological memoirs which the Clarendon Press are publishing. The volume is nearly ready, and may be expected shortly.

MESSRS. CROSBY LOCKWOOD AND SON have published a second edition of M. Eissler's "Metallurgy of Gold." The work has been enlarged by about 150 pages and 40 additional illustrations.

WE have received the seventh part of Cassell's "New Popular Educator," which will be completed in forty-eight parts. This part contains a lithograph presenting the constellations visible in Britain.

MESSRS. C. GRIFFIN AND CO. have published the sixth annual issue of the "Year-book of the Scientific and Learned Societies of Great Britain and Ireland." The work, which is compiled from official sources, comprises lists of the papers read during 1888 before Societies engaged in fourteen departments of research.

THE additions to the Zoological Society's Gardens during the past week include an Indian Wolf (*Canis pallipes* ♀) from India, presented by Major C. S. Skipton, R.A.; two Stone Curlews (*Œdicnemus scolopax*), British, presented by Mr. Brunsden; a Golden Eagle (*Aquila chrysaëtus*) from Inverness-shire, presented by Mr. Thomas G. Henderson; a Cape Mole-rat (*Georychus capensis*), a Geometric Tortoise (*Testudo geometrica*), four Tuberculated Tortoises (*Homopus femoralis*), six Narrow-headed Toads (*Bufo angusticeps*), thirty-four Gray's Frogs (*Rana grayi*), a Spotted Slowworm (*Acontias meleagris*), rom Cape Colony, South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; a Puff Adder (*Vipera arietans*) from the Cape of Good Hope, presented by Mr. F. Streatfield; six European Tree Frogs (*Hyla arborea*), European, presented Mr. H. Bendelack Hewetson, F.Z.S.; a Rhesus Monkey (*Macacus rhesus* ♀) rom India, deposited; two White-eyed Ducks (*Nyroca ferruginea*), European, two Black-necked Swans (*Cygnus nigricollis*) from Antarctic America, two Lineated Kaleege (*Euplocamus lineatus*) from Tenasserim, a Brazilian Tortoise (*Testudo tabulata*) from South America, a Blackish Sternothere (*Sternothœrus subniger*) from Madagascar, purchased; a Persian Gazelle (*Gazella subgutterosa*), two Chinchillas (*Chinchilla lanigera*), four Long-fronted Gerbilles (*Gerbillus longifrons*), born in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *MAY* 12–18.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 12

Sun rises, 4h. 15m.; souths, 11h. 56m. 10·1s.; daily decrease of southing, 1·2s.; sets, 19h. 38m.: right asc. on meridian, 3h. 17·9m.; decl. 18° 15′ N. Sidereal Time at Sunset, 11h. 1m.

Moon (Full on May 15, 7h.) rises, 15h. 55m.; souths, 21h. 57m.; sets, 3h. 45m.*: right asc. on meridian, 13h. 20·1m.; decl. 2° 58′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian h. m.	Declination on meridian ° ′
Mercury..	4 48	13 10	21 32	4 32·4	24 8 N.
Venus.....	3 21	10 45	18 9	2 6·3	15 16 N.
Mars......	4 38	12 37	20 36	3 58·6	20 55 N.
Jupiter....	23 18*	3 14	7 10	18 34·0	22 58 S.
Saturn....	10 7	17 45	1 23*	9 7·8	17 42 N.
Uranus...	16 17	21 46	3 15*	13 9·8	6 42 S.
Neptune..	4 50	12 37	20 24	3 59·4	18 56 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

May.	h.	
18	3	Jupiter in conjunction with and 0° 15′ south of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	May 16,	1 11	*m*
R Aurigæ	5 8·3	53 28 N.	,, 13,		*M*
W Leonis	10 47·8	14 18 N.	,, 13,		*M*
T Ursæ Majoris	12 31·3	60 6 N.	,, 15,		*m*
δ Libræ	14 55·1	8 5 S.	,, 13,	23 25	*m*
U Ophiuchi	17 10·9	1 20 N.	,, 17,	0 10	*m*
R Scuti	18 41·6	5 50 S.	,, 13,		*M*
β Lyræ	18 46·0	13 14 N.	,, 14,	22 30	*M*
U Aquilæ	19 23·4	7 16 S.	,, 18,	1 0	*M*
R Capricorni	20 5·1	14 36 S.	,, 17,		*M*
X Cygni	20 39·1	35 11 N.	,, 17,	2 0	*m*
T Vulpeculæ	20 46·8	27 50 N.	,, 13,	1 0	*M*
δ Cephei	22 25·1	57 51 N.	,, 15,	21 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near α Coronæ	232°	27 N.	Faint. Rather slow.
,, η Aquilæ	295	0	May 15. Very slow.
From Delphinus	313	15 N.	Swift. Streaks.

GEOGRAPHICAL NOTES.

DR. H. MEYER, in a paper read before the Geographical Society of Leipzig, deals with the snowfall on the summit of Kilimanjaro. Having shown that the southern and south-eastern slopes of the mountain are exposed during summer to the south-eastern trade winds, while the summit rises into the region of the anti-trades, and that local winds, sometimes of considerable force, ascend the mountain slope during the day, and descend during the night, he explains how these winds produce rain and snow. Dr. Meyer looks upon the wall of ice which stopped his further progress as the edge of a cap of *névé* which covers the summit, and which, owing to the combined influence of the wind and radiation, has melted away on its northern side. On the south, however, it seems to form a true glacier, which issues from the ancient crater-trough of Kibo.

SOME of the conclusions come to by Dr. K. W. Schmidt, in his paper on the soil and climate of German East Africa, in the current number of *Petermann's Mitteilungen*, are worth giving in detail. The wooded and mountainous region of Usambara and the western part of Bondei, in consequence of the favourable character of the soil, the copious rainfall, and extensive irrigation, may be truly described as fertile, and in the opinion of the author these countries have a great future before them. West of Usambara extend vast steppes, utterly unfit for cultivation. The mountain mass of Kilimanjaro, composed of recent volcanic, basaltic, and trachytic rocks, and clothed with a wealth of forests, should become of great importance. The physical condition of the country between the Pangani and the Wami are apparently not very favourable. Westwards the country of Nguru, in its geological formation, its magnificent forests, its numerous streams, and its meteorological conditions, resembles Usambara. Southern Useguha, as far as the Kingani and Gerengere, including the districts of Udoe and Ukewere, is nothing but a vast waterless steppe. Ukami, in its western part, abounds in lofty forest-clad mountains and rushing streams, and its soil is well adapted for cultivation; the soil of the eastern part of Ukami is, on the other hand, composed almost exclusively of quartz pebbles and gravel. Immediately to the west of Ukami stretches the vast desolate Mkata steppe, beyond which rises the mountainous country of Usagara, divided by the Mukondokwa River. The plain of Farhani, traversed by the river, is fertile and well populated. The mountainous district of Usagara itself suffers from a lack of streams, and also from the sparsely wooded character of its mountain slopes, at least in the eastern part. The country of Khutu, in its various river valleys, might furnish soil suitable for extensive cultivation. The general results of Dr. Schmidt's observations is to show that there is a great difference in the fertility and consequent value of the various countries comprised within the German protectorate in East Equatorial Africa, and that while there is a considerable extent of extremely fertile territory, the greater part does not appear to be capable of remunerative cultivation.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE'S EASTER DREDGING CRUISE.

THE Liverpool Salvage Association's s.s. *Hyæna* left the Mersey on Thursday, April 18, on her fifth scientific cruise under the direction of the Liverpool Marine Biology Committee. The old gunboat had been generously placed at the disposal of the L.M.B.C. for five days, and the proposed course was to cross to Port Erin, at the south end of the Isle of Man, and then dredge southwards to Holyhead through the deepest water to be found in this district; then to work along the coast of Anglesey to Puffin Island, and from that back to Liverpool. Besides the ordinary dredging and tow-netting operations, it was hoped that two interesting new methods of collecting would be tried on this cruise: (1) the submarine electric light, which gave such good results in the *Hyæna* expedition of last summer, was to be used as an attraction in the nets let down to the bottom at considerably greater depths than was the case in last year's experiments at Ramsey and Port Erin; (2) Mr. W. E. Hoyle's new tow-net (recently described in the Proc. Biol. Soc. Liverpool, vol. iii.), which can be opened and closed at any required depth, so as to insure that the contents were captured in a particular stratum of water, was to be taken with the view of trying how it worked.

After the first day, however, the weather although fine on land became very unfavourable for marine work, and the programme had to be considerably altered. Thursday was spent in crossing to Port Erin. On Friday morning we steamed south-west towards the deep water, but a strong wind was blowing, and after a haul of the dredge in 27 fathoms, about five miles out, some bottom and surface tow-netting, a sounding in 50 fathoms, and a further run to about nine miles from land, it was found that the heavy rolling of the vessel rendered dredging operations impossible out in the open sea; so the *Hyæna* was put about and returned to Port Erin, where tow-netting and other work was carried on in the bay. The following day the wind was still stronger, so it was decided to give up the Anglesey part of the cruise and devote the remaining days to shore and shallow-water work round the south end of the Isle of Man. Accordingly the rocks at Port Erin, Port St. Mary, Poyllvaaish Bay, and Fleshwick Bay were explored on the third day, while on the fourth most of the day was spent on board the *Hyæna*, at anchor in Port Erin Bay. Tow-nets were let down, both on the surface and weighted so as to reach the bottom, and a small dredge with a long canvas net was taken out in a boat and used for obtaining samples of mud and sand to examine for small animals, such as Foraminifera, Copepoda, and Ostracoda. The strong wind blowing was utilized by Captain Young, who suggested floating tow-nets across the bay with life-buoys, and devised a sailing apparatus, consisting of an old life-buoy rigged up with a mast and sail, and having a tow-net suspended from it, which was let out carrying a long line to leeward and was then hauled in, the net keeping distended and working well during both the outward and the return journeys. Another surface-net was even rigged up attached to a large kite, but this did not work satisfactorily.

In the afternoon the *Hyæna* made two runs from Port Erin southwards to the Calf, dredging homewards with the wind, and got two excellent hauls, which contained amongst other things: *Sarcodictyon catenata*, *Stichaster roseus*, *Palmipes membranaceus*, *Porania pulvillus*, *Adamsia palliata*, and *Fagurus prideauxii*, *Ebalia* sp., *Lyonsia norvegica*, *Pectunculus glycimeris*, and *Ascidia venosa*.

After dark on two consecutive nights the electric light was used for a couple of hours in collecting bottom and surface free-swimming animals round the ship, in much the same way as during last summer's cruise. A pair of large arc lamps of 2000 candle-power each were hoisted up in such a position as to illuminate the deck and cast a bright light on the water for some distance on each side of the ship. Three submarine incandescent lamps of 50 candle-power each were then fitted in the mouths of tow-nets and were let down, two of them to the bottom at a depth of 5 fathoms, and the third to a foot or so below the surface of the sea. Each of these nets was put out twice, so that we got four bottom hauls and two surface hauls with the electric light tow-nets. Another tow-net, without any lamp, was let over the side of the *Hyæna*, and lay in the brightly illuminated surface water. All these nets were stationary, but were kept fairly distended by the tide. At the same time Mr. I. C. Thompson was rowed round and round the ship dragging an ordinary tow-net in the bright area. Consequently all the nets were, on this occasion, used in water lighted up, the surface nets being in the glare of the 4000 candle-power lamps, while the bottom nets were further from this bright light, but had each their own smaller lamps. All gave, so far as we yet know, from a cursory examination, practically similar results which are markedly different from both the bottom and surface gatherings taken at the same place during the previous day. The electric light gatherings contain chiefly Schizopoda, Cumacea, Amphipoda, and a few Copepoda. The Cumacea are the most marked feature, they are very abundant, and form a conspicuous characteristic in the gathering whenever it is transferred from the net into a glass jar. In none of the daylight tow-nettings, either bottom or surface during the cruise, was a single Cumacean obtained, while every gathering on the two nights when we had the electric light going contained Cumacea in abundance. I think there can be little doubt that those captured in the surface-nets had been attracted from the bottom by our brilliant deck-lights, which had been shining for fully half an hour before the nets were put over.

On the fifth day the *Hyæna* started in the morning from Port Erin and arrived at Liverpool at midnight. A little dredging and tow-netting was done on the way. A good haul was obtained from a stony and shelly bottom, at about 15 miles south-east of the Chicken Rock, depth 30 fathoms, which yielded large numbers of Polyzoa, chiefly incrusting forms. At this spot also, it being the deepest water on our track from Port Erin to Liverpool, we let the electric lamp down to the bottom in a tow-net twice, and got gatherings consisting mainly of Copepoda, *Sagitta*, Amphipoda, Zoëas, and other larval forms.

That free-swimming Crustaceans are attracted to a stationary net by the electric light may now be considered established beyond doubt; and that the illuminated tow-net can be used in, at least, such moderately deep water as is commonly met with in dredging round our coasts was evident to all who saw the success with which the net was worked on board the *Hyæna* in 30 fathoms.

The various tow-net gatherings and dredged collections were as usual preserved and brought home, and are now in the hands of the specialists who are working at the different groups of animals for the Liverpool Bay "Fauna."

W. A. HERDMAN.

SOCIETIES AND ACADEMIES.

LONDON.

Linnean Society, May 2.—Mr. C. B. Clarke, F.R.S., in the chair.—With reference to a recent exhibition, by Mr. D. Morris, of leaves of different species, or varieties, of plants included under *Erythroxylon Coca*, Lamarck, Mr. Thomas Christy made some remarks on the leaves of a variety from Japan. These he described as brittle and thin, with hardly any trace of cocaine, though yielding 8 per cent. of crystallizable substance. The thicker leaves of the Peruvian plant yielded more cocaine, though at first rejected on account of their more glutinous nature.—Mr. John Carruthers read a short paper on the Cystocarps, hitherto undescribed, of a well-known seaweed, *Rhodymenia palmata*, upon which remarks were made by Mr. G. Murray and Mr. A. W. Bennett.—The second part of a monograph of the *Thelephoreæ* was communicated by Mr. G. Massee.—Mr. Mitten contributed a paper on all the known species of *Musci* and *Hepaticæ* recorded from Japan. An interesting discussion followed on the character of the Japanese flora, in which Mr. J. G. Baker, Dr. Braithwaite, and Mr. G. Murray took part.

Geological Society, April 17.—W. T. Blanford, F.R.S., President, in the chair.—The following communications were read:—On the production of secondary minerals at shear-zones in the crystalline rocks of the Malvern Hills, by Charles Callaway. In a previous communication the author had contended that many of the schists of the Malvern Hills were of igneous origin. Thus, mica-gneiss had been formed from granite, hornblende-gneiss from diorite, mica-schist from felsite, and injection-schists from veined complexes which had been subjected to compression. As a further instalment towards the elucidation of the genesis of the Malvern schists, he discussed the changes which the respective minerals of the massive rocks had undergone in the process of schist-making.—The northern slopes of Cader Idris, by Grenville A. J. Cole and A. V. Jennings. From the publication of Mr. Aikin's paper in the Transactions of the Geological Society in 1829 to the second edition of the

Survey Memoir on North Wales, the relations of the geological and physical features of Cader Idris have been pointed out in some detail. The present paper dealt with the nature of the eruptions that took place in this area, and the characters of their products at successive stratigraphical horizons.—Discussions followed the reading of both of these papers.

Paris.

Academy of Sciences, April 29.—M. Hermite in the chair.—On a means of obtaining photographs of true chromatic value by the use of coloured glasses, by M. G. Lippmann. By the judicious employment of green, yellow, and red glass in the way here explained, excellent results have been obtained even with present plates, notwithstanding their greater sensitiveness to blue. The impressions are described as clear and free from brown patches, the green foliage, the red or yellow draperies, instead of yielding brown tints, being reproduced in delicately modelled design as in a well-executed engraving.—Loss and gain of nitrogen as determined by the experiments carried on at Grignon from 1875–89, by M. P. P. Dehérain. A general survey of the results of these experiments leads to the conclusion that all soils containing considerable quantities of nitrogen in combination, say two grammes to the kilogramme, lose, if cultivated without manure, far more nitrogen than is absorbed by the crops, but in proportions varying according to the nature of those crops—more with beetroot, less with maize grown for fodder, still less with potatoes and wheat. But when the ground has thus been impoverished, no longer containing more than 1·45 or 1·50 grammes to the kilogramme, the losses ceases and the ground begins, on the contrary, to recover a certain proportion of nitrogen, the gain being much greater on grass-grown than on tilled lands.—Underground growth, seed, and affinities of the Sigillaria, by M. Grand'Eury. The author, who has had a favourable opportunity of studying these fossil plants in the Carboniferous formations of the Gard, confirms the view always held by Prof. Williamson, that they are true Cryptogams of the vascular order, despite the radiated structure of the wood. But they are not directly connected with any living type, and form a family of fossil plants which entirely disappeared towards the close of the Palæozoic period.—Two eruptions observed on the sun in September 1888, by le Père Jules Fényi. These eruptions, observed on September 5 and 6, are described as of an extremely violent character, and as all the more remarkable because occurring at the epoch of minimum intensity. Both appear to have taken place about the same region of the solar disk, and the protuberance accompanying the first contained the vapours of several metals, such as sodium, barium, and iron, besides two very bright red rays of an unknown element, one between B and C, the other between B and *a*.—On the alloy of the standard international kilogramme, by M. J. Violle. The alloy of platinum and iridium in the proportion of 10 per 100, prepared with the greatest care by M. Matthey, is here found to be still somewhat defective. M. Violle's researches show that an alloy of 9 parts platinum and 1 iridium yields more uniform and accurate results both as regards density and specific heat. The density thus obtained is an absolute constant, incapable of further modification under cold-hammering, annealing, or any other severe test.—Dilatation and compression of carbonic acid, by M. Ch. Antoine. In a previous note (January 21, 1889), the author showed that the reciprocal β of the coefficient of dilatation under constant pressure is given by the relation—

$$\beta = \frac{pv_s}{\delta} - t_s,$$

δ being a constant coefficient, t_s and v_s the temperature and volume at saturation under the pressure p. Here he finds that more simple values may be obtained both for pv_s and β.—On electrolytic polarization by metals, by M. N. Piltschikoff. A general result of these researches is that one metal may be polarized by another.—On the formation of earths containing nitrogen, by MM. A. Müntz and V. Marcano. The authors describe numerous caves in Venezuela, both on the coast ranges and on the slopes of the Andes, which contain vast deposits richly charged with nitrates and interspersed with the remains of large extinct animals. The bones are so friable that they crumble to dust at contact of the finger; hence the difficulty of determining the species. They consist almost exclusively of phosphate of lime; carbonate of lime is entirely absent, and there are but slight traces of organic matter. In these caves, sheltered from the action of rain-water, the nitrogen yielded by the nitrified organic remains was gradually accumulated. In some places the beds are over 30 feet thick, containing from 4 to 30 per 100 of nitrate of calcium, and from 5 to 60 of phosphate of calcium.—On the art of utilizing statistics, by M. Delauney. With a view to the better utilization of statistical returns, especially in the sphere of meteorology, the author here proposes a solution of the problem: Given the statistics of a phenomenon, to find a certain method by means of which the laws controlling that phenomenon may be discovered.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Sylvan Folk: J. Watson (Unwin).—Moral Order and Progress: S. Alexander (Trübner).—Physiological Notes on Primary Education: M. P. Jacobi (Putnam).—Die Meteorologie Ihrem Neuesten Standpunkte Gemäss und Mit Besonderer Berücksichtigung Geographischer Fragen: Dr. S. Günther (München, Ackermann).—Report of Rainfall in Washington Territory, &c., for two to forty years (Washington).—Haunts of Nature: H. W. S. Worsley-Benison (Stock).—A Table of Specific Gravity for Solids and Liquids (Constants of Nature, Part 1): F. W. Clarke (Macmillan).—Half a Century of Australian Progress: W. Westgarth (Low).—Electric Light for the Million: A. F. Guy (Simpkin).—A Syllabus of Modern Plane Geometry: (Macmillan).—Geological Magazine, May (Trübner).—Annalen der Physik und Chemie, 1889, No. 5 (Leipzig, Barth).—Quarterly Journal of Microscopical Science, May (Churchill).—Proceedings of the Royal Society of Edinburgh, vol. xv. No. 128.—Proceedings of the Royal Society of Edinburgh, Session 1888–89, vol. xvi. pp. 65-128.—Journal of Physiology, April (Cambridge).—Meteorological Record, vol. viii. No. 31 (Stanford).—Quarterly Journal of the Royal Meteorological Society, January (Stanford).—Quarterly Weather Report, Part 4, October–December, 1879 (Eyre and Spottiswoode).—Hourly Readings, 1886 (Eyre and Spottiswoode).

CONTENTS.

THURSDAY, MAY 16, 1889.

BORNEO.

Borneo: Entdeckungsreisen und Untersuchungen; Gegenwärtiger Stand der Geologischen Kenntnisse; Verbreitung der Nutzbaren Mineralien. Von Dr. Theodor Posewitz. (Berlin: Friedlander, 1889.)

IN the work before us, Dr. Theodor Posewitz, of the Hungarian Geological Institute, gives the results of his three years' personal explorations in the Island of Borneo, with which he has incorporated the more important observations which are recorded in the literature of the subject. The larger portion of this literature being in Dutch, it is, as a whole, not very widely known; it is, accordingly, a matter of considerable importance to have it here summarized and critically examined by so competent an authority.

The three parts into which the volume is divided are: (1) Political and Historical; (2) Geological; and (3) Economic Mineralogy. Each of these parts is further subdivided into a number of clearly-defined sections, so that there is no difficulty experienced in at once mastering the range and contents of the work, which are further indicated by means of four excellent maps, showing respectively, (1) the routes of travellers, (2) the political divisions, (3) the geological structure, and (4) the distribution of useful minerals.

We are told, in Part I., that two-thirds of the island belong to the Dutch, but that the States on the north coast are more or less under British influence.

The history of exploration, as conducted by the Dutch, is treated separately from that which originated in connection with British colonial enterprise. During the last century, only one extensive journey was undertaken in Dutch Borneo, and scientific exploration was then altogether prohibited.

The genuine exploration of the country did not begin till 1820–30, when a Natural History Commission was established in Batavia, and its members undertook to investigate and describe various islands. Among others, Horner, G. Müller, Dr. Schwäner, and Von Gaffron devoted themselves to Borneo, and to the two last we owe our knowledge of South Borneo. Between the years 1850–60, systematic explorations for useful minerals were carried on by Dutch engineers in South-West Borneo, and these explorations have been recently resumed, after an interval of twenty years.

To Alexander Dalrymple, who travelled in 1769, we are indebted for our first knowledge of North Borneo; other early travellers were Burns, Hugh Low, and Spenser St. John, who visited Sarawak, Brunei, and the north-east coast, and ascended the Kina Balu Mountains. Among later travellers, Crocker and H. Everett merit special notice; as also do the courageous pioneers in the British North Borneo Company's territory—Dobrée, Peltzer, Wetti, Von Donop, Pryer, and F. Hatton.

With regard to the geological and physical structure, which are dealt with in Part II., we are told that there is no uninterrupted central mountain chain in Borneo, though such is represented on most maps. Isolated mountains occur at intervals, surmounting table-lands which extend in a north-east to south-west direction; but it is not yet decided whether a regular chain exists in any part of the interior. The Kina Balu Mountains, which have a maximum elevation of 13,698 feet, are, so far as is at present known, the highest in the island; they are situated in the territory of the British North Borneo Company.

The largest rivers—the Barito, Kapuas, Redjang, and Mahakkam—rise in the centre of the island.

The geological structure is remarkably free from complexity. The isolated mountains are of slate or schist penetrated by granite and diorite—conditions, it may be remarked, which are in many countries accompanied by the occurrence of mineral veins; this also seems to be the case in Borneo.

Succeeding these are rocks of Devonian age, in which auriferous veins occur. Till quite recently no formations had been recognized between them and the Tertiary deposits which have long been known, but Carboniferous strata (mountain limestone), which it is believed occur throughout a large area in Northern Borneo, have within the last few years been recognized, and Cretaceous rocks have been discovered in a single locality in West Borneo.

Tertiary formations belonging to several subdivisions are distributed over considerable areas; they form the plateaus through and above which the mountain chains rise. The older Tertiary strata were first studied by Verbeek and Pengaron in South Borneo. They are divisible into sandstone, marl, and limestone groups. The majority of the coral deposits occur in the sandstone, and the limestones consist mainly of wide-spreading coral reefs. These older Tertiary strata are often much disturbed and broken by intrusive masses of andesite. Oligocene strata are only known in East Borneo, where they include extensive deposits of coal.

The diluvium of our author is of considerable economic importance. It spreads over wide undulating tracts surrounding the Tertiary hills. It includes the principal sources of the gold and diamonds which, together with coal, constitute the most valuable mineral resources of the island. From the diluvium to the alluvium which is in process of formation at present, there is a gradual transition.

There are no evidences of any post-Tertiary volcanic energy in Borneo. The Kina Balu Mountains, at one time thought to be volcanic, are now known to consist of ancient eruptive masses. Earthquakes occur, but rarely, and so far as is known they originate in neighbouring islands.

In West Borneo a deposit which appears to be identical with one form of Indian laterite, is described as resulting from the weathering of the rocks. A similar laterite occurs near Singapore.

Taking a general survey of the probable geological history of Borneo, it appears that, up to the beginning of the Tertiary period, what now forms one united island consisted of an archipelago like that between Singapore and Banka. After the deposit of the Tertiary strata there followed a period when the island had the form of the Celebes. A tradition among the natives, that the sea formerly reached to the foot of the mountains, is referred to as confirming the view that the present form of the island has only been acquired recently.

The useful minerals are described in Part III., and their distribution is indicated on the map already referred to. Of most of them Dr. Posewitz has previously published separate descriptive monographs.

The rich coal-fields are first described. The seams are exposed in many river cuttings in Sarawak and Brunei. Coal also occurs on the Island of Labuan and in Sabah. There are said to be rich and extensive deposits in East Borneo also, but they have not been worked.

Gold is of the next importance to coal as a mineral product. Mining in the older formations has hitherto not proved remunerative, the best field being from the diluvial deposits, which are worked almost exclusively by Chinese. The richest gold regions are in the south-east, near Tanah Laut and Kusan, on both sides of the auriferous Meatus Mountains; and in the north-east, in the Chinese districts of West Borneo and Sarawak. Recently, what promise to be rich gold deposits have been discovered in the Upper Segamah River in Sabah.

The production of gold was much more considerable formerly than it is at present. In West Borneo it amounts annually to 120,000–150,000 kilogrammes, and in Sarawak it amounted to 28,281 kilogrammes in 1886.

Diamonds are not, comparatively speaking, so abundant as gold, but they occur in the same deposits. They are searched for by Chinese. Since the introduction of the cheaper Cape diamonds, the production has fallen. In 1884, 2727 carats were exported from West Borneo, and 1200 carats from Sarawak in 1886.

Dr. Posewitz refers to the late Prof. Lewis's speculation as to the connection between diamonds and serpentine (*Peridotite*) (NATURE, vol. xxxvi. p. 571), but states that it is not yet known how far his conclusion is correct, that diamonds and platinum are only found in Borneo in streams which traverse areas containing serpentine. Indeed, it may be added that serpentine is of rare occurrence in the principal diamond regions of India, and in some of them none whatever has been observed.

The famous "diamond" of 367 carats, known as the "Matan," from the territorial title of the Rajah to whom it belongs, has been estimated to be worth £269,378 (Crawfurd). The Dutch made very large offers of money and warlike material for it early in the present century, but these were always refused. The stone, it now appears, was examined in 1868, and proved to be only a rock crystal with a specific gravity of 2·63, thus confirming doubts perviously expressed as to its being really a diamond.

Platinum is of very local occurrence in Tanah Laut only.

Antimony and quicksilver only occur, so far as is known, in sufficient quantities to be regularly mined in Sarawak.

Iron ores are widely distributed, but are of no present economic value. The introduction of cheap European iron has put an end to the native iron industry, as is the case, too, in many parts of India.

Dr. Posewitz states that the condition of mining industries generally in Borneo is at present very poor. In the south, private coal-mines existed, but were put an end to by an insurrection. The well-known Government mines at Pengaron ceased working after thirty-six years' existence, as they were no longer remunerative. A private company has now commenced to work valuable mines on the east coast. In Sarawak, mines have been worked by the Government since 1881, and in 1886 produced 44,167 tons. In Labuan, mines were also worked for some time, but are now closed. The principal source of supply at present is from Brunei (Muara coal). It is hoped that in the British North Borneo Company's territory extensive workings of gold and coal will be established.

It is impossible to give here an adequate idea of the careful details with which each topic discussed in this work is illustrated. At the same time there is a highly meritorious conciseness of treatment which, together with the soundness of the author's views and his careful quotation of his authorities, makes the work a text-book for which it is to be hoped that a competent translator into English and an enterprising publisher will be found. It is emphatically a work which was much wanted, as our knowledge of the geology of this important island has hitherto been most fragmentary and imperfect, and we trust, therefore, that, ere long, steps may be taken to make Dr. Posewitz's labours better known to English readers. V. B.

GRAPHICS.

Graphics; or, the Art of Calculation by drawing Lines, applied especially to Mechanical Engineering. With an Atlas of Diagrams. By Robert H. Smith, Professor of Engineering, Mason College, Birmingham. Part I. (London: Longmans, Green, and Co., 1889.)

MAXWELL was the first, according to the Introduction of the present treatise, to state the principles in a very complete and general manner by which stress-diagrams are drawn, in the *Phil. Mag.*, xxvii., 1864; and also in the Trans. Roy. Soc. Edinburgh, vol. xxvi.

But Maxwell himself is careful to point out that he derived the original idea from Mr. W. P. Taylor, or at least was unaware of his previous use of the method.

The method is of much greater antiquity, and can be traced through Moseley's "Mechanical Principles of Engineering and Architecture," 1843, to Hutton's "Course of Mathematics," 1811, and probably still further back.

It is, however, only of recent years that Maxwell's treatment has been followed up and developed by Cremona, Culmann, von Ott, and others; and now the method is considered indispensable in practice for the calculation of the stresses in bridges, roofs, and engineering and architectural structures generally.

Two great advantages of the graphic method recommend it to the practical man—the first, that the diagram is itself a check upon the correctness of its construction; and the second, that the numerical results of the diagram are read off on a scale only to the really practically significant number of figures, the very roughness and imperfection of the draughtsman's work showing the margin of variation to be allowed for.

As to the relative rapidity of the graphic method compared with ordinary numerical calculation by logarithms and arithmetical processes, the author points out that, while for a single isolated calculation the graphic method may easily be distanced, it is in the long-continued series of operations of the same character required by the engineer, shipbuilder, or constructor in general, that the graphic method takes the lead once the calculator has got his mental operations thought out, and his instruments in good order; for which purpose Chapter I., on instruments, gives valuable hints and information.

Chapter II. explains succinctly the plan of the book in its applications to graph-arithmetic, Chapter III.; graph-algebra, Chapter IV.; grapho-trigonometry and mensuration, Chapter V., &c., and lastly, grapho-dynamics, experimental and mathematical tabulation.

It is in the later chapters that the full power of the graphic method is developed, but in the earlier chapters the student is exercised by well-chosen practical examples in the mental operations and manipulation required in the advanced processes. The student of ordinary mathematical processes will find here graphic solutions of geometrical loci, and the solution of quadratic, cubic, and other algebraical and trigonometrical equations, illustrated by carefully-drawn diagrams in the atlas of plates. But the author appears to underrate the value of the planimeter on p. 63, in its application to the evaluation of the irregular areas encountered in indicator diagrams, shipbuilding, and railway engineering.

In Chrystal's "Algebra," the importance of the graphic solution in integers of the loci represented by indeterminate equations of the first and second degree is pointed out; and in the present work the graphic solution of the general quadratic and cubic equations by means of a carefully-drawn curve, $y = \frac{x^2}{10}$, or $y = \frac{x^3}{100}$, and its intersections with a straight line, is also developed, and illustrated in the Atlas of Diagrams.

The logarithmic curve, $y = e^x$, or 10^x, would also be useful for the graphic solution of transcendental equations of the form—

$$Aa^x + Dx + F = 0,$$

required in the problem of the hydraulic buffer.

Again, in trigonometry, the solution of the equation—

$$a \cos \theta + b \sin \theta = c,$$

or the summations $\Sigma \cos (a + n\beta)$ or $\Sigma' \sin (a + n\beta)$ by a graphical method, or drawing Lissajous's figures graphically, would tend to impart freshness to a subject at present running in a narrow dry rut. Paper ruled into small squares of centimetres and millimetres, suitable for graphic methods, can be obtained in Germany, of Carl Schleicher and Schüll in Düren, for instance.

It is curious to notice that the fresh and original ideas and treatment of elementary mathemathical subjects due to Maxwell and Clifford are to be found embodied and adopted only in practical and technical treatises, such as the present work. Elementary mathematical treatises are in danger of becoming as dry and orthodox as a religious creed: examiners, on the one hand, are forbidden to set ideas out of the groove of a few antiquated text-books; and examinees, on the other hand, dare not allow themselves to learn new ideas and methods, for fear of finding themselves at a disadvantage with old-fashioned examiners.

Some reflections on p. 181 of the present work on the radiant-energy-carrying ether show, however, that the author allows himself occasionally to indulge in the purely abstract speculations dear to Sir W. Thomson and Mr. Macfarlane Gray.

Chapter IX., on the "Kinematics of Mechanisms," covers much the same ground as Kennedy's "Mechanics of Machinery," and follows Reauleaux's treatment in his "Kinematik." Chapter X., on "Static Structures, Frames, or Linkages," and Chapter XI., on "Flat Static Structures, containing Beam-Links," contain the applications of the graphic method to problems most commonly encountered by the practical designer.

The consideration of "Solid Static Structures" in Chapter XII. follows very usefully as a check upon the *in plano* treatment of the subject in the two preceding chapters. The failure of many very scientifically-designed bridges in America has shown that it is not sufficient to treat the beam in elevation only, as if it was a vertical plane structure; but that the torsional rigidity is of importance whenever the load is applied in the least degree eccentrically.

A glossary of special terms and symbols is inserted at the beginning, containing without redundancy the new terminology useful in this subject; and an index completes the work, in which we should like to have seen a complete list of books in English bearing on this and kindred subjects, such as Cotterill's "Applied Mechanics,' Eagles's "Constructive Geometry," Clarke's "Graphic Statics," Wormell's "Plotting, or Graphic Arithmetic"; also McLay's articles on "Geometrical Drawing," now appearing in the *Practical Engineer.*

The author promises a second part dealing with "The Distribution of Stress and Strain," "The Strength, Stiffness, and Design of Beams and Struts," "Economy of Weight in Structures," "Stresses in Redundant Structures," "Statics and Dynamics of Machines," "Frictional Efficiency," "Governors and Fly-wheels," "Valve Gears," "Practical Thermodynamics of Furnaces, Boilers, and Engines," "Hydrostatics and Hydrokinetics of Ships and Hydraulic Machines"—all subjects of great practical and theoretical interest, to which we shall look forward with much pleasure. A. G. GREENHILL.

THE CHEMICAL ANALYSIS OF IRON.

The Chemical Analysis of Iron. By Andrew Alexander Blair. (London: Whittaker and Co. Philadelphia: J. B. Lippincott, 1888.)

OF all the branches of quantitative analysis practised for the control of industrial processes, none is of greater importance than that which concerns iron. The precise relationship of chemical composition to mechanical properties is by no means fully ascertained; but a great deal of excellent work has been done in this direction, and we know in several cases the kind of variation in physical properties which is, *cæteris paribus*, to be expected to accompany a variation in the quantity of one constituent. We know, moreover, how extraordinarily great this physical change may be, compared with the change in composition. When we reflect that a quantity, which in most other technical analyses is within the error of experiment, may become the criterion by which an iron is appraised, we must recognize the necessity of accurate methods of analysis for this particular commodity.

The present work is stated to be a "complete account of all the best known methods for the analysis of iron, steel, pig-iron, iron-ore, limestone, slag, clay, sand, coal, coke, and furnace and producer gases," and we may say at once that the book realizes its title in a very admirable way.

The author brings high credentials to his task, having—as chief chemist to the United States Board, appointed to test iron, steel, and other metals in 1875, and as chief chemist to the United States Geological Survey and tenth census 1880—devoted many years to the subject. He records, he says, the results of his own experience, and there is a personal flavour about the work such as is too seldom found in modern hand-books. One feels in reading the descriptions of apparatus, processes, and precautions, that they are not merely what the author has collated, but what he has seen and done and learned. There are many novel arrangements of apparatus described, many improvements of detail in various analytical processes, and altogether the subject is handled in a thoroughly authoritative and practical manner.

The most striking thing, however, is the elaborateness and refinement insisted upon in the performance of the more important operations. There is no attempt to compromise unwisely between accuracy and rapidity—these two *desiderata* are treated separately. Thus there is a method described for determining silicon with elaborate precautions by volatilization in a current of chlorine, and another in which the amount of silicon in a pig-iron can be determined in twelve minutes from the time the ladle is put into the molten iron.

The book begins with a description of apparatus and manipulation required for sampling, and subsequent analytical operations. This portion of the work will no doubt be found useful—but we regard it as sufficient rather than exhaustive. We can scarcely say as much of the following 20 pages, devoted to reagents. There seems to be some uncertainty as to the chemical knowledge expected from the operator. The information about chlorine that it is a yellowish gas, about two and a half times heavier than air, sparingly soluble in water, and the somewhat obvious truth which completes this description, that "when required it must be made," will probably fall flat upon a person who a few lines further on is expected to know that chromic acid should not be dried by filter-paper. And again, if one is to be told the equations which represent the preparation of ammonium sulphide, why should not one be told *why* it "becomes yellow by age, or on exposure to air"? We think this portion needs revision; superfluous information should be removed, and the descriptions should be made more complete. We think also that it would be much to the benefit of the very large number of half-informed persons engaged in the routine analysis of iron, if the theory of the analytical process were described always at the beginning of a chapter instead of being interspersed (and then often imperfectly) with the details of operations. In these respects Mr. Blair's work might be improved, but in the main features there is no fault either of omission or commission. The book is beautifully printed, is supplied with full marginal notes and luxurious woodcuts, and is altogether a much more presentable volume than the British analyst is accustomed to have about him. We have no doubt it will be very cordially welcomed in the numerous iron and steel works laboratories of this country.

OUR BOOK SHELF.

Agricultural Canada: a Record of Progress. By W. Fream, B.Sc., LL.D., &c. (1889.)

LAST year, Dr. Fream, as Commissioner of the Canadian Government, visited Canada, for the purpose of reporting upon the position and prospects of agriculture in the Dominion, and his Report has now been published under the direction of the Government of Canada. The author, who was well fitted for the task by his previous knowledge of Canada, appears to have visited every province in the Dominion, from Nova Scotia on the Atlantic seaboard to British Columbia on the Pacific. Numerous details concerning the climate, and the geological, botanical, and other natural features of the northern half of the North American continent, are interwoven with the more prosaic facts bearing upon the agricultural development of an area as large as that of Europe. Some parts of the Dominion, little known even in Canada, are dealt with in special detail. The fine rolling prairie occupying North-Western Manitoba, and stretching away through Assiniboia to the banks of the North Saskatchewan River, is selected for favourable notice, but this region has at present to be explored on horseback or on a "buckboard." Far away to the west, in Alberta, there appears to be another fertile and beautiful region awaiting development, in the Rosebud country, which includes the Red Deer Valley. The attempt to unravel the complicated surface features between the Rocky Mountains and the Pacific deserves notice, and some reference is made to the little-known Kootenay district. The Commissioner extended his travels across an arm of the Pacific to Vancouver Island, the southern point of which is capable of considerable agricultural development. To the production of cattle, horses, grain, cheese, and fruit, the agricultural energies of the Dominion are chiefly directed, and the Report strongly urges the Government not to moderate one iota the stringency of the quarantine regulations, whereby alone Canadian cattle are kept free from contagious disease. The Report, as a whole, might advantageously take the place of nine-tenths of the school-books which profess to deal with Canada.

Longmans' School Arithmetic. By F. E. Marshall, M.A., and J. W. Welsford, M.A. (London: Longmans, 1889.)

THIS work owes much of its value to its being drawn up on the lines laid down by De Morgan. This is shown by the importance attached by the authors to computation in the early part of the work, and by the copious use of diagrams in the chapters devoted to vulgar fractions. A moving cause to such a casting of the book is the importance which has been attached to De Morgan's methods in the recently issued report of the Arithmetic Committee of the Association for the Improvement of Geometrical Teaching. With such an admirer of the Professor as the late President of the Association is, on the said Committee, we should expect such a result. Much space is devoted to oral exercises; this being so will account, in a measure, for the written explanations not being quite so full as we have seen them in other text-books. The treatment of recurring decimal fractions is thorough, the unitary method is employed in the solution of examples, and considerable care has been expended upon the commercial arithmetic. A large body of exercises is furnished in the text for solution, and very many specimens of examination papers as well as papers of miscellaneous exercises come at the end. There are a few small matters, in an appendix and elsewhere, which call for more careful and precise statement, but on the whole the work is calculated to be useful, and we can recommend it for school use.

Glimpses of Feverland: or, A Cruise in West African Waters. By Archer P. Crouch, B.A. Oxon. (London: Sampson Low, 1889.)

IN this volume Mr. Crouch presents a record of the impressions made upon him by the land and people of certain portions of West Africa, which he visited in connection with the laying of a cable to put various places, principally French and Portuguese, in telegraphic communication with Europe. A large part of the book is devoted to an account of what he saw during his passage from Accra, on the Gold Coast, to the Portuguese island of St. Thomé. Afterwards we have a full description of St. Thomé and St. Paul de Loanda, and in several concluding chapters the author sums up the incidents of his voyage homewards. Mr. Crouch is so good an observer, and has so frank and lively a style, that his narrative, taken as a whole, is fresh and interesting, although his subject is often, apart from his treatment of it, dreary enough. He is particularly successful in those passages in which he seeks to give his readers glimpses of native customs and superstitions. It is worthy of note that he has formed a very unfavourable judgment as to the intellectual and moral qualities of the Negro race; but on this question, with regard to which he differs widely from Mr. Stanley, he perhaps speaks rather more positively than the extent of his experience warrants.

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 Meteoritic Theory.

I HAVE during the past six months been led from the study of our own atmosphere to consider certain phenomena relating on the one hand to the solar *atmo-physics*, and on the other hand to the evolution of our own globe and its atmosphere. There has thus arisen in my mind a system of cosmogony which has led me, quite independent of Mr. Norman Lockyer's published course of reasoning, back to a meteoric theory that will, I hope, be acceptable to yourself and others. Awaiting the preparation of these views for publication, I have had occasion to look over the report on the total eclipse of the sun, July 1878 (Professional Papers of the Signal Service, No. 1, Washington, 1881). I quote from pp. 49 and 50 some paragraphs to show the connection between views then held and those at which I have recently arrived.

Washington, April 29. CLEVELAND ABBE.

"Under these circumstances, I could but regard the suggestion that occurred to me on July 29 as a slight but important extension and modification of the views previously held. . . . It amounted to saying that a large part of the phenomena of the outer corona is essentially non-solar, having to do with cold meteoric matter that is beyond the solar gaseous atmosphere and is shining by reflected light, . . . rushing on its way to plunge into the sun's atmosphere, where, within a few hours, it would be dissipated. . . . That these beams were due to wholly new meteor streams . . . now for the first time approaching the sun. . . . I am now inclined to extend this view to very many of the radiating dark and bright lines observed during eclipses, and would explain most of them as due to brightly illuminated groups and streams of meteors and to large meteors followed by trains. . . . Those meteors that enter the solar atmosphere and become incandescent will of course shine with a greatly increased splendour, and thus constitute a portion of the inner corona; these thus show us the limit of the gaseous atmosphere of the sun. . . . The extreme limit may be located at a distance of five minutes (of arc) above the sun's surface, and is very likely to be less than this. . . . Meteors glow as shooting-stars when they strike our atmosphere with a relative velocity of from twenty to forty miles per second, and at an altitude of about one hundred miles, where the density of the atmosphere may be about 3×10^{-9} times that which prevails at the surface. Now these same meteors will, when they have approached to within 130,000 miles of the sun's surface, have a momentum at least a hundred times greater than that with which they enter the outer limit of the earth's atmosphere; therefore we are allowed to assume the density of the outer limit of the supposed solar atmosphere to be but the hundredth part of that of the earth, or 3×10^{-11}; this gives us for the base of the solar atmosphere a density and a pressure quite within plausible bounds."

The Structure and Distribution of Coral Reefs.

THOSE who have read the additional appendix in the edition just published of Mr. Darwin's work on coral reefs will doubtless have observed that whilst the recent evidence there produced against the theory of subsidence lies chiefly in observations on living reefs in the Florida seas, in the Western Pacific, and in the Indian Ocean, the new testimony advanced on behalf of the theory is in the main indirect in bearing, and is based on assumptions that have yet to be proved.

Referring to the latter evidence in the order of mention, I come first to the 90-fathom reef off Socotra, a reef that is assumed to have been lowered by a movement of subsidence into its present position. So defective is our knowledge of the depths at which coral reefs may grow, and so incomplete is our acquaintance with the complex agencies that combine to produce a coral reef or to limit and prevent its growth, that the inference respecting the depth of the Socotra reef may be truly characterized as based on an unproved assumption. At present our acquaintance with the fauna of the submarine slopes of tropical islands in the Indian and Pacific Oceans, between the depths of 20 and 100 fathoms, is of the scantiest description; and we are not in a position to hazard even a guess on the subject, much less to assume that an island like Socotra has experienced a movement of subsidence because it possesses a reef "submerged in some places to a depth of over 90 fathoms." It is owing to our ignorance of the fauna in these depths that it has not been possible to identify the great numbers of minute molluscan shells, which occurred in the upraised post-Tertiary muds discovered by me in the Solomon Islands; and it is of the lack of such knowledge that Prof. K. Martin in his recent great work on the Tertiary formations of Java naturally complains. Surely, when the biologist is fain to acknowledge his want of acquaintance with the matter, and when as a consequence the palæontologist and the geologist have to bring their labours to a standstill from the lack of comparative material, it seems rather dangerous for the coral reef speculator to assume what has never been properly examined.

If, therefore, we have yet to determine the limit of depth of the growth of coral reefs, we are scarcely in a position to advance as evidence in behalf of subsidence the thickness of certain upraised beds of coral limestone in the West Indies and in the Sandwich Islands. Even if such evidence should be ascertained to be valid in itself, it must be remembered that Mr. Murray in his theory places no limit to the possible thickness of coral reefs, and that in the outward growth of a reef a considerable thickness may be produced. There was, in truth, no circumstance more impressed on my mind in the Cocos-Keeling Islands than the seaward extension of coral reefs.

Once more, however, I would impress on future investigators the extent of our ignorance of the depths in which coral reefs may form. In one of my papers (Proc. Roy. Soc. Edin., 1885-86, p. 887) I have pointed out that the estimates of observers in different regions vary between 5 and 40 fathoms. It is also singular how different observers may vary in the conclusions they draw from the same lines of soundings. The soundings off Keeling Atoll were made by Captain Fitzroy himself, and he places the limit of depth at 7 fathoms ("Voy. *Adventure* and *Beagle*," ii. 634); whilst his companion, Mr. Darwin, judging from the same soundings, concluded that it lay between 12 and 20 fathoms. In truth, as long since pointed out by Prof. Semper, the whole question of the depth of the reef-coral zone has never been methodically investigated. It never occurred to Mr. Darwin or Prof. Dana that coral reefs might grow in depths *beyond the belt of sand that apparently limited their growth.* Yet such I found to be actually the case on the slopes of Keeling Atoll, where Captain Fitzroy's soundings were taken. Few, in fact, who have read the work of the young naturalist of the *Beagle*, can sufficiently realize how scanty were the data on which the fundamental inference of the theory of subsidence was based; and I may safely add that few must be the scientific questions that have been settled on a scantier basis of observation than that relating to the depths at which reef-corals grow.

With regard to the sections exhibiting the submarine profile of the reef of Masámarhu Island, I was first at a loss to understand why their character should be advanced as favouring the idea of a movement of subsidence, since, when they first appeared in NATURE (vol. xxxvi. p. 413), I regarded them as favouring Mr. Murray's views. However, it soon appeared that this opinion was based on our inextensive acquaintance with the habits of corals, especially with the limiting causes of their extension in depth. The "ditches" shown in these sections I look upon as indicating the formation of barrier-reefs at considerable depths, and as giving remarkable support to my views on the origin of these reefs. In the paper above quoted I have been led by the observations of Agassiz in the Florida seas, and by my own in the Solomon Islands, to the conclusion that the main determining condition of the depth in which reef-corals thrive is to be found in the injurious effect on coral growth of the sand and sediment produced by the breakers, and that the distribution of these materials is dependent on the angle of the seaward submarine slope and on other less important circumstances.

It follows from this that in those localities where the submarine slope is moderate, a barrier-reef will form beyond the belt of detritus derived from the shore-reef inside it. But when the slope is fairly steep, as in the case of Keeling Atoll, the reef *débris* will cover an area of much less horizontal extent, and, as at these islands, an off-lying line of coral shoals will spring up at a distance only of 150 or 200 yards from the inner reef. Should, however, the slope be precipitous, as at Masámarhu Island, the reef *débris* will extend to considerable depths; and beyond the area thus covered with sand and gravel, a line of reef will in the course of time grow upwards, giving rise to the so-called "ditches" of the sections.

Reefs of all classes, as I hold, have a two-fold mode of growth seawards. There is first the advancement of the outer edge of a reef on its own talus, as dwelt upon by Mr. Murray. In the second place, they grow seaward by a reclaiming process, whether they be fringing, barrier, or circular reefs. The distribution of the sand and *débris*, guided by the angle of the submarine slope, determines, as above shown, this second mode of growth, which may result, as at Keeling Atoll, in a line of adjacent coral banks that ultimately reclaim a new strip and add it to the width of the reef, or a more distant barrier reef may appear at the surface, the lagoon of which silts up and is choked with coral in the course of ages, or, as at Masámarhu Island, there may occur a deeply-submerged barrier-reef that can be discovered only by methodical soundings.

Let us take the instance of Keeling Atoll to illustrate the present condition of this controversy. In a series of papers on this celebrated atoll, that I am preparing for the Royal Scottish Geographical Society, I have shown that the direct evidence of subsidence adduced in its case by Mr. Darwin is, according to Mr. G. C. Ross, its present proprietor, founded in error. In truth, Mr. H. O. Forbes, during his visit in 1878, observed evidence leading in his opinion towards a movement of upheaval. In default, then, of direct evidence, we have to look for the indirect proofs to certain *a priori* considerations, based on a few soundings that appeared to demonstrate once and for all the limit of depth of the reef-coral zone, a subject concerning which we still have very incomplete data. Then we are transported across the Indian Ocean to the 90-fathom reef of Socotra, the origin of which, for the reason just stated, is hidden in mystery. Afterwards, appeal is made to the thickness of reef limestones in Cuba and in the Sandwich Islands, limestones which, it is alleged, could only have been formed during subsidence, notwithstanding that their exact nature has not yet been determined, and in spite of the circumstance that reefs can attain a considerable thickness, as Mr. Murray rightly holds, solely by their outward growth.

If a visitor from another planet, having thus far followed the discussion, were to inquire in an apologetic manner whether, instead of going to the other hemisphere for evidence we had methodically endeavoured to investigate the problem on the spot, by patiently studying the complex agencies at work on this atoll, by carefully inquiring into the changes of the past, and by interpreting through their aid the processes of the present, we should be obliged to answer: "Scarcely at all. A theory advanced on the very threshold of such an investigation explained so well our limited knowledge by a movement of subsidence, that it is only of late years that doubts have arisen and that a new theory has been advanced opening up the lines of research to which you refer."

H. B. GUPPY.

"Bambangala."

I SHALL be glad if you will allow me to call the attention of those who visit the Congo Free State to the curious antelope called "*Bambangala*," which is spoken of by Captain Bateman in his "The First Ascent of the Kasai," lately published by Messrs. George Philip and Son. Captain Bateman describes it as being "in size as large as a mule; of a bright chestnut colour, striped with creamy white, much in the manner of a zebra, on the back and sides, and dappled on the neck and flanks."

From the form of the horns shown in the figure (which, by the kind permission of Messrs. George Philip and Son, is here reproduced from Captain Bateman's book), it would appear that this antelope must belong to the genus *Tragelaphus*, but probably to a new species.

I should be very glad to examine specimens of the head and horns of this antelope, in case any of your correspondents in the Congo should meet with it, or to have some further information on the subject from those who have visited that region.

P. L. SCLATER.

Zoological Society of London, 3 Hanover Square, London, W., May 7.

Inclusion of the Foot in the Abdominal Cavity of a Duckling.

A DUCKLING, four days old, sent from Eastry in Kent, hatched on April 25, 1889, presented the above curious abnormality. The right lower extremity was normal in every respect; the left appeared on superficial examination to be absent. An incision made through the skin over the left flank at once disclosed the left limb, the joints being flexed to their utmost extent, and the thigh adducted, so that it lay in contact with the abdominal muscles of the left side; at the tibio-tarsal joint the limb passed through the wall of the abdomen, a few millimetres above the symphysis pubis. A portion of the yolk-sac protruded at the aperture by which the foot penetrated the abdominal wall. Opening the abdomen showed the remainder of the yolk-sac, its connection with the ileum, and the left foot lying upon the surface of the intestines. This included foot was fully developed, having a complete web, and being covered with scales. An adhesion existed between the outer surface of the yolk-sac and the left leg in the region of its tibio-tarsal joint, and there were also adhesions of the sac to the skin of the abdomen, covering the lower part of the tibial muscles. This adhesion of the yolk-sac to the leg had apparently taken place after the full development of the limb; and the yolk-sac, in the course of its withdrawal into the cavity of the abdomen, had apparently drawn the foot in with it. The withdrawal of the yolk-sac is generally held to be brought about by the absorption of its contents; if the above explanation of the existing condition be correct, a considerable force must be exerted by this act of absorption if it is capable of dragging the foot, from its normal position, into the cavity of the abdomen.

E. WAYMOUTH REID.

St. Mary's Hospital, W., May 6.

Atmospheric Electricity.

I SEND you the following account of a curious, and, I believe, rare electrical phenomenon witnessed last week by a friend of mine and myself.

We had, in the course of a long mountain ramble, reached the summit of Elidyr Fawr (3033 feet), a mountain lying to the north-east of Llanberis, and about four miles north of Snowdon. Being a short distance in front of my friend, I sat down and rested with my back to the cairn, sheltering myself from a cold south wind which was blowing with considerable velocity. In about two minutes I heard a curious buzzing sound commence, apparently proceeding from the top of the post set up not long ago by the Ordnance surveyors. I had heard the same noise about three years ago while descending the *arête* of the Weisshorn, and on that occasion, as on this, there was a south wind blowing, accompanied by snow—on the Weisshorn in large flakes, on Elidyr Fawr in fine powdery flakes. On the Weisshorn, for above an hour every rock seemed to emit the peculiar buzzing noise, and our ice-axes did the same. We were in too great a hurry, however, to pay much attention to the phenomenon. A day or two after, I related my experience to a gentleman, Mr. Powell—who, I trust, will forgive me for mentioning his name—and learned from him that he had had a similar experience on the Unter-Gabelhorn, near Zermatt. The day was on that occasion, if I remember right, clear, when the noise was heard, followed in a short time by a flash, and a shout from two of the party that they were struck. No harm was done by the shock, but the sensation was described as being like that which would be felt if every hair of the head were caught hold of and violently twisted. Having heard the sound before, I readily recognized it on Elidyr Fawr, and resolved if possible to study the phenomenon more closely. I first climbed on to the cairn, and found that the sound proceeded from the whole surface of the wood for about two feet from the top of the post. I then raised my stick, which had an iron point, and found that the sound began to proceed from it directly a height of about six feet from the ground was reached. I then put my hand on the part emitting the sound, but could feel nothing. On putting my stick down, and keeping my hand up, the sound proceeded from my hand—from more or less of it according as I raised it higher or lower—and I imagined that on the back of my hand the sensation of being very slightly pricked in many places was perceptible. My friend was much impressed by the peculiarity and intensity of the sound, and agreed with me that it would not be wise to stay long. As we proceeded along the ridge, after a slight drop, we rose again, and while standing on some rocks, the noise began in our caps, accompanied by such an agitation of the hair that it quite seemed as if we had literally a "bee in the bonnet." There was no sound of thunder, and in the course of about half an hour the snow-storm passed away, not however before we had descended far below the enchanted summit.

C. A. C. BOWLKER.

Halo of the Moon and Formation of Peculiarly Shaped Clouds at Oxford.

I NOTICED the following very beautiful phenomenon on the night following May 8, and it seems to me worth recording. At 9.45 p.m. the moon was surrounded by a very large halo, the sky being quite clear in the immediate vicinity of the same, with the exception of a small accumulation of clouds at the lower part of the halo (to the left of the spectator).

At 10.45 the halo had completely disappeared, and a large cloud was obscuring it and the moon. The margin of the cloud was split up into tongue-like protuberances. At 11.20 the halo had again appeared, but it was not so bright; the moon was hidden from the spectator by some clouds.

At 11.30 the clouds had disappeared, and the moon was shining out brightly, but the halo was only very slightly visible, and that only at its highest point. Just before it began to disappear gradually, some of the clouds with the peculiar tongue-like protuberances already mentioned were formed, but they disappeared again after a few minutes. As was to be expected, we had rain on the following day, and some already during the same night.

I need only just mention that the halo is supposed to be produced by the refraction of light by crystals of ice. Brewster proved this by viewing the sun through some plate-glass on which he had allowed some alum to crystallize out in a thin sheet, when he saw a number of rings closely resembling halos.

OTTO V. DARBISHIRE.

Balliol College, Oxford.

Spherical Eggs.

THE problem of packing the greatest number of equal spheres into a given space, to which Prof. Aldis has drawn attention in your columns, is the simplest case of a more general problem which I have employed in my theory of crystallization (Cam. Phil. Trans., vol. xiv. part 3)—that is, the packing of the greatest number of equal and similar ellipsoids into a given space. The solution is that the ellipsoids should be arranged in a manner similar to that described for spheres by Profs. Aldis and Greenhill, so that every ellipsoid be touched by twelve others, and, further, that all the ellipsoids be similarly situated. The curious result comes out that so long as the ellipsoids are all similarly situated the orientation of the axes makes no difference in the number of them per unit volume. They may be turned about, provided they are all similarly turned, without affecting the ratio between the space filled by them and the unfilled space between them.

In the case of spheres, if tangent planes be drawn through all the points where the spheres touch one another, they will cut up space into regular rhombic dodecahedrons, every sphere being circumscribed by such a dodecahedron. Now, of plane-faced figures which can be described about a sphere and which will exactly fill space, the smallest in volume is the rhombic dodecahedron; hence the spheres arranged in the way described occupy the minimum volume. In like manner if tangent planes be drawn through all the points where the ellipsoids touch one another, they will divide space into dodecahedrons with quadrilateral faces, which will be unsymmetrical, but will be all similar and equal. If the ellipsoids be all turned in a similar manner the dodecahedrons will alter in form but not in volume. These dodecahedrons are the smallest which can be described about the ellipsoids consistently with the condition that they shall exactly fill space. The condition of similarity in the situation of the ellipsoids involves the consequence that, if we consider one ellipsoid and the twelve others which touch it, four planes can be drawn each passing through the centres of seven ellipsoids. The points of contact of the ellipsoids will lie in those planes, and the tangent planes through these points will be parallel to the diameters conjugate to those planes. Other geometrical properties follow which do not concern the present problem.

Cambridge, May 10. G. D. LIVEING.

Columnar Structure in Ice.

THERE are several notices in existence on the subject of the columnar structure of ice, to which attention has been called by Mr. La Touche (NATURE, May 9, p. 35). For instance, a letter by myself in the first volume of NATURE (p. 481), which contains references to sundry cases of the occurrence of the structure in Britain and in other parts of Europe, and offers a suggestion as to the cause. The structure may often be seen, if looked for, and is be t exhibited when a very gradual thaw follows a hard frost.

T. G. BONNEY.

SCARLET FEVER AND COW DISEASE.

FEW questions have within recent years more engrossed the attention of the veterinary and medical professions of this country, and have been the subject of greater or more acute controversy, than the relation of human scarlet fever to cow disease. As is well known, the Medical Department of the Local Government Board, through the Reports of Mr. Power, Dr. Cameron, and Dr. Klein (1886), have brought forward a formidable array of facts, by which it was established that, in an epidemic of scarlet fever prevailing towards the end of 1885 in the north of London, the contagium was distributed through a milk supply derived from particular milch cows at a dairy farm at Hendon, which cows were affected with a specific eruptive and visceral disease—the Hendon disease. It was further shown (Report of the Medical Officer of the Local Government Board, 1887) that this cow disease is to be considered as cow scarlatina, and that both human and cow scarlatina are associated with and caused by a microbe, the *Streptococcus scarlatinæ*.

The veterinary profession, headed by the Agricultural Department of the Privy Council, have been foremost in the opposition to these statements. In the Report "On Eruptive Diseases of the Teats and Udders of Cows," issued towards the end of 1888 by Prof. Brown, the chief of the Agricultural Department, a superabundance of opinions were forthcoming, and, as often happens under the circumstances, fact has appeared for a while in danger of being smothered in the confusion engendered. But, happily, facts are stubborn things, and not easily stifled. However much trampled on, facts are ever prone to reassert themselves and to multiply, and one result of the cow controversy has been that the recently issued Report of the Medical Officer of the Local Government Board gives promise of a new and abundant crop of them. The first subject bearing on this controversy and dealt with in the recent volume is the significance of the *Streptococcus scarlatinæ*. Many and various have been the assertions as to this microbe being an unessential concomitant of the disease. The experiments now made by Dr. Klein (Appendix B, No. 1, Section A.), with artificial cultures of the *Streptococcus scarlatinæ* on recently-calved milch cows, show that an eruptive and visceral disease is produced in these cows which closely resembles the Hendon disease, and consequently lend firm support to the view previously enunciated by the Medical Department that the *Streptococcus scarlatinæ* is the real microbe of scarlet fever.

Amongst a further array of facts therein marshalled, some that are historical obtain, in view of the cow controversy, fresh interest and importance. It is pointed out (Section B.) that, before the time of Jenner, "cow-pox" was the familiar name given to every sort of sore on cows' teats; that, with recognition by Jenner of a form of sore denominated by him *variolæ vaccinæ*, one particular cow-pox obtained the distinctive name of "true," while all others became designated as "spurious"; and that, except for Ceely's notable endeavours to obtain better knowledge, "spurious cow-pox," blister-pock, and the like vague terms continued to be used indifferently for all sores on the teats and udders that were not "true cow-pox." So the matter stood for eighty years, until at the Hendon farm a second definite member of this group was recognized by Mr. Power, when the old division into true and spurious cow-pox became manifestly insufficient. It was now seen that the name "spurious cow-pox" had in all probability been used to cover a variety of sores having essential differences in nature, just as, until the time of Jenner, the name "cow-pock" had covered along with various other things the disease which we know as vaccinia. But it is one thing to have learnt the essential nature of those sores of the cow that are concerned with vaccinia or scarlatina in the human subject, and quite another thing to affirm the distinguishing characters by which these may be recognized from other sores that once on a time laid claim to being equally with them "cow-pox" or "spurious cow-pox." It is very obvious, too, that our new discontent with the name "spurious cow-pox" does not at once give us knowledge of those sores which remain on the list, while it is equally clear that there are many kinds of such sores.

In these circumstances there was nothing to be done but to begin over again the study of cow-poxes with a view to learning of each one its complete natural history. And this has been the procedure of the Medical Department, with the result that a considerable instalment of positive knowledge respecting certain cow eruptions is afforded in the Report already referred to. When it is said that there was no alternative procedure to that adopted by the Medical Department, no more is meant than that from the scientific stand-point no alternative was possible. Other ways there were, of course, of dealing with the subject, as, for instance, in its "practical" or trade aspects, or from the sentimental point of view. That adopted by the Veterinary Department of the Privy Council is not easy of definition, but it may be described as a method of composite character by which uncertain science and excess of sentiment are oddly interjumbled.

It has consisted in flat denial of the possibility of cow scarlatina, along with reversion in the matter of cow-poxes to the attitude of the cow-man of pre-Jennerian days. Thus Prof. Brown, in the earlier pages of his Report in denial of cow scarlatina, speaks indifferently of "eruptive disease among cows," "udder disease among cows," "outbreaks of udder disease common as usual," "a very common eruptive affection which is usually called cow-pox by dairymen," and the like. And throughout his Report Prof. Brown studiously avoids giving a name to any udder disease or diseases with which he is dealing. Only once does his reader, when referred to Plate 4, at the end of Prof. Brown's volume, obtain hope of some definite nomenclature; but he turns to the plate in question only to be confronted with such terms as "blister-pock" and "blue-pock"—terms of the pre-Jennerian prototype. Having thus smoothed the way for discovery of a cow-pox (or "Hendon disease") not associated with scarlatina among consumers of the milk of the affected animals, Prof. Brown would seem to exercise almost superfluous caution in his phrasing of the following passage at p. vii. of his Report:—"Leaving for the present the subject of the original Hendon cow disease in 1885–86, it is necessary to refer to outbreaks of the same *or similar*[1] cow disease which occurred at Hendon and elsewhere in 1887–88." Be this as it may, he had of course no difficulty whatever in finding instances of one or another cow malady, which it pleased him to call "Hendon disease," not associated with scarlatina among persons consuming the implicated milk. This sufficed for Prof. Brown, and for a while, perhaps, he was altogether content.

But Prof. Brown's confidence in his own opinion, fortified as it had been by his failure in the early stage of his investigation to find any udder affection associated with illness of scarlatinal sort among consumers of the milk of the affected cows, was destined later on to receive somewhat rude shocks. Prof. McFadyean, a coadjutor of Prof. Brown's, having made discovery at Edinburgh of an udder malady associated with sore throat among persons consuming the milk of the cows affected by it, Prof. Brown, on personal examination of the Edinburgh cows, was constrained to admit for this disease clinical characters distinguishing it from any that he himself had been investigating, and pathological features very similar to those of the original Hendon disease.

Of this Edinburgh disease (the pathology and ætiology of which are described by Dr. Klein in Appendix B., No. 2) Prof. McFadyean notes that it "differed in every important respect from true cow-pox," and that (like the Hendon disease) "it did not cause sores on the hands of the milkers." Here, then, on the evidence of the Veterinary Department, was a cow malady that was not cow-pox,

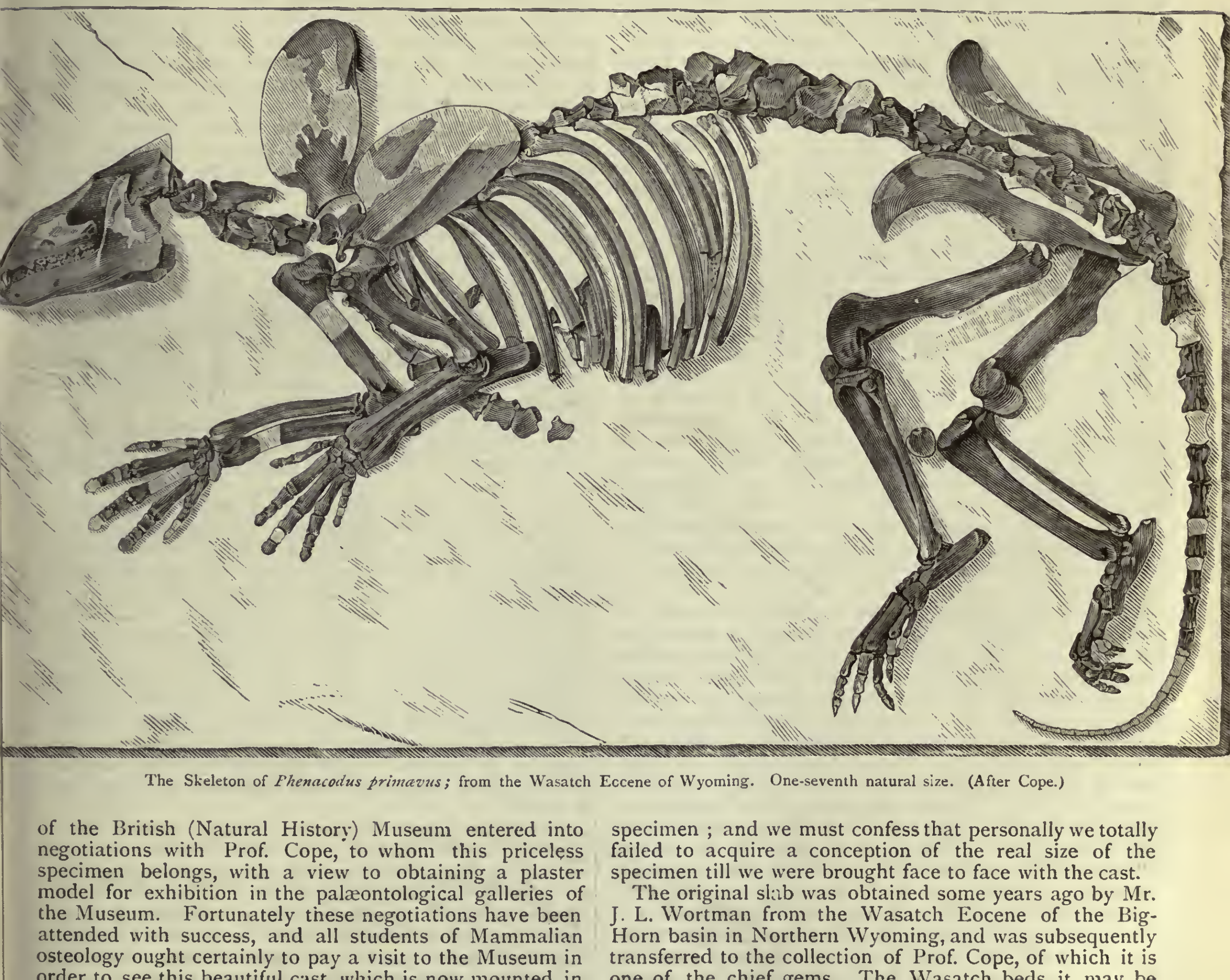
[1] The italics are ours.

that was not the "Hendon disease" of Prof. Brown, but which was associated with throat illness among consumers of the milk of the affected cows—just such a cow malady, in fact, as the Medical Department stated could have, and had, existed without recognition by veterinary surgeons.

SKELETON OF PHENACODUS.

ALL readers of the *American Naturalist* must be familiar with a striking woodcut of the entire skeleton of a peculiar fossil Ungulate, which occurs throughout a long series of numbers among the advertisements, and bears the following somewhat startling subscription, viz. "The five-toed horse—the ancestor of lemurs and man." This figure we are enabled, through the courtesy of Prof. Cope, to reproduce in the accompanying woodcut. The name given by its describer, Prof. E. D. Cope, of Philadelphia, to the animal of which the skeleton is so marvellously preserved, is *Phenacodus primævus;* the genus forming one of the best-known representatives of that very curious extinct group of generalized Ungulates for which the Professor has proposed the name Condylarthra.

Till quite recently those zoologists who have not enjoyed the good fortune of visiting the United States have been acquainted with this remarkable and unique fossil only by description and figures; the largest figure being the fine plate in Prof. Cope's magnificent quarto work on the "Tertiary Vertebrata of the West," published a few years ago by the United States Government among the Reports of the Geological Survey of the States. Some months ago, however, the Keeper of the Geological Department of the British (Natural History) Museum entered into negotiations with Prof. Cope, to whom this priceless specimen belongs, with a view to obtaining a plaster model for exhibition in the palæontological galleries of the Museum. Fortunately these negotiations have been attended with success, and all students of Mammalian osteology ought certainly to pay a visit to the Museum in order to see this beautiful cast, which is now mounted in its place, and is, we will venture to say, of far more value to the student than many of the real but fragmentary fossil specimens for which large prices have been paid. We may indeed congratulate the popular Keeper of the Geological Department in not hesitating to pay what we believe was a somewhat heavy price for the acquisition of this cast.



The Skeleton of *Phenacodus primævus;* from the Wasatch Eocene of Wyoming. One-seventh natural size. (After Cope.)

No figures could, indeed, possibly give an adequate idea of the marvellous state of preservation of the original specimen; and we must confess that personally we totally failed to acquire a conception of the real size of the specimen till we were brought face to face with the cast.

The original slab was obtained some years ago by Mr. J. L. Wortman from the Wasatch Eocene of the Big-Horn basin in Northern Wyoming, and was subsequently transferred to the collection of Prof. Cope, of which it is one of the chief gems. The Wasatch beds, it may be observed, are low down in the Eocene, and when we consider that so many of even the Upper Eocene Mammals of Europe are known only by isolated and often imperfect skulls, teeth, or limb-bones, we are struck with the marvellous preservation of the American form. The dimensions of the slab are about 49 by 28 inches; and Prof. Cope describes the animal as intermediate in point of size between a sheep and a tapir. The animal lies on its right side, with the tail bent suddenly down behind the posterior limbs, and the shoulder-blades thrown up from their proper position some distance above the line of the vertebral column. The skull is almost entire, and although the scapulæ are imperfect, and the right pectoral limb has sustained some losses, all the bones of the skeleton are in their original juxtaposition, so that we may note the arrangement of the bones of the carpus or tarsus almost as well as in the skeleton of a recent type. It strikes us, indeed, that it would have been quite easy to have extracted the skull and many of the bones of the limbs from the matrix, and made entire casts from them, which could have been placed in cavities in the cast from the original slab.

The chief importance of this and other American specimens of fossil Mammals belonging to totally extinct types is their completeness, whereby we are enabled at once to gain a very fair idea of the affinities of the animals to which they belonged. In Europe, with the exception of the well-known Mammals of the Upper Eocene (or Lower Oligocene) of the Paris basin, our efforts are nearly always hampered by the imperfect nature of our specimens—as witness the question whether the limb-bones from Hordwell described by Kowalewsky are or are not referable to the *Dichodon* of Owen, which was founded upon the evidence of the skull—so that we can very rarely speak confidently and fully as to the affinities of any particular form. It may, indeed, be stated, without any fear of contradiction, that we could never have hoped to have attained anything like our present knowledge as to the mutual affinities of the various sub-orders (or orders) of Ungulate Mammals and their relations to other groups, had it not been for the fortunate discoveries of such a host of well-preserved specimens in the Tertiaries of the United States. And we may here express the obligations which all European students are under to those palæontologists who, like Messrs. Cope, Leidy, Marsh, Osborn, Scott, and others, have laboured so indefatigably to collect and describe the Vertebrate faunas of past epochs in the so-called New World. In expressing thus briefly our obligations to these eminent exponents of the life-history of a former world, we must, however, not omit also to mention the enlightened liberality of the Government and of various learned Societies in the States, which have furnished the funds necessary to render these treasures available to the world, through the means of the magnificent publications in which they are described.

In concluding this brief notice of the new treasure recently aquired by our National Museum, we may say a few words regarding some of the chief characters of the Condylarthrous Ungulates. One of their most essential features is the comparatively simple arrangement of the bones of the wrist and ankle joints (carpus and tarsus); the various rows preserving their original distinction, and having only very slight mutual interlocking. In this respect, this group agrees with the existing Hyracoidea so closely that Prof. Cope has considered himself justified in brigading the two groups together under the common title of Taxeopoda. Usually the dentition comprises the full number of teeth found in those higher, or placental, Mammals in which the teeth are differentiated into groups; and very generally the cheek-teeth have their crowns formed on what is known as the bunodont type. That is to say, their crowns are low, and carry three or more low and blunt tubercles, as exemplified in the pig and in man. Further, the eye or canine teeth are well developed, and recall those of the Carnivora. Again, the humerus, or bone of the upper arm, has a foramen at its lower extremity, which is totally unknown in all other Ungulates, and likewise recalls the Carnivora and some of the lower orders. The digits are nearly always five in number, and their terminal joints are so pointed as frequently to render it difficult to say whether their coverings should be termed nails or hoofs. The femur, or leg-bone, has a third trochanter, like that of existing Perissodactylate Ungulates; and the ankle-bone, or astragalus, has its lower articular surface uniformly convex, instead of flattened or facetted as in all modern Ungulates. The astragalus and the wrist joint are, indeed, very similar to the same parts in the generalized Carnivora of the Eocene. The tail was larger and heavier than in any existing Ungulate, and was thus more like that of many Carnivora, such as the wolf. In walking, it appears that the three middle toes of each foot touched the ground, whilst the first and fifth toes stuck out on the sides and behind, after the fashion obtaining with the second and fifth toes of the pigs.

The curious approximation made in the osteology of this remarkable type of Mammal to the generalized Carnivora of the Eocene, to which Prof. Cope has applied the name of Creodonta, is so marked that Dr. Max Schlosser, of Munich, considers that we are now justified in regarding the Ungulates and the Carnivores as divergent branches of a single primitive stock. *Phenacodus* is regarded, moreover, by Prof. Cope, as the ancestral type from which a number of the more specialized Ungulates have been derived; and there appears every probability that this genus should be placed as one of the earlier links in the chain which culminates in the modern horse.

Recently, however, the American Professor has proposed to include in the Taxeopoda not only the Hyracoidea and Condylarthra (which it was originally formed to receive), but also the Primates of English zoologists, which it is proposed to divide into the Daubentoidea, represented by the existing aye-aye (*Chiromys*) and the extinct *Mixodectes*; the Quadrumana, embracing the other lemurs and monkeys; and the Anthropomorpha, which is taken to include the man-like apes and man. A complex genealogical tree is given, in which the *Phenacodontidæ* are represented as not only the progenitors of the other Ungulates, but also as giving origin on the one hand to the so-called Daubentoidea, and on the other to the Quadrumana, from which the Anthropomorpha are derived as a secondary branch from the Eocene Lemuroid *Anaptomorphidæ*, which group is itself derived from the *Adapidæ*, as represented by the well-known *Adapis* of the Upper Eocene of Europe.

Now, with all due respect to Prof. Cope, we venture to say that no English zoologist will be inclined to accept a classification which includes in a single "order" such widely different forms as man and the hyrax, while the other Ungulates are apparently regarded as constituting a totally distinct order. Again, in regard to the genealogical tree it appears to us to be incomprehensible how an order like the Primates, all the members of which are furnished with fully-developed clavicles, can have taken origin from an Ungulate type like *Phenacodus*, in which it appears that those bones are totally wanting. While, therefore, fully recognizing the great interest of *Phenacodus* as an ancestral type, we totally fail to see how it can also be regarded as the "ancestor of lemurs and of man."

R. L.

THE IRON AND STEEL INSTITUTE.

THE twentieth session of the Iron and Steel Institute was opened on Wednesday, May 8, when the President, Sir James Kitson, gave his inaugural address, which was of a technical character, and was devoted mainly to the consideration of the best Yorkshire iron as an industrial product; but the subject of iron alloys, to which we shall refer again, the extending application of iron and steel for railways and ships, and other matters of interest, such as technical education and the revival of trade, were also referred to.

The first paper read was one on the alloys of nickel and steel, by Mr. James Riley. This led to a very lengthy and interesting discussion, from which it appeared, as has often occurred in similar instances, that another metallurgist had been working in the same direction for a considerable time. The results obtained by Mr. F. J. Hall, of Messrs. Jessop's, of Sheffield, and Mr. Riley are very similar in character, but whilst the former appears to have made what may be called industrial experiments, those of the latter have been mainly confined to the laboratory. Nickel can be made to form an alloy with steel, in quantities varying from a hardly appreciable amount up to as much as 50 per cent.; the alloy does not require an excessively high temperature to melt it, special attention is not necessary in its production, the resulting metal is definite in character, and is easily worked both under the hammer and in the rolls. A very remarkable increase in the tensile strength and elasticity of steel is produced by alloying it with nickel. Among many tests given by Mr. Riley, the following specially referred to by him may be cited:—"In No. 6, the carbon present (0·22) is low enough to enable us to make comparison with ordinary mild steel, which would give (when annealed) results about as follows: elastic limit, 16 tons, breaking strain, 30 tons, extension 23 per cent. on 8 inches, and contraction of area 48 per cent. Therefore, in this case the addition of 4·7 per cent. of nickel has raised the elastic limit from 16 up to 28 tons, and the breaking strain from 30 up to 40·6 tons, without impairing the elongation, or contraction of area to any noticeable extent." In his remarks Mr. Hall referred to his applications of nickel steel to gun barrels, propeller blades, and other purposes during recent years, and concluded by observing that in an experiment he had made about twelve months ago, he had obtained with nickel steel a tensile strength of 97 tons per square inch, with an elongation of 7 per cent. Another important point with regard to nickel steel referred to by Mr. Riley is its non-corrosibility when the alloy contains 25 per cent. of nickel, for, with low proportions of nickel, ordinary mild steel and nickel steel appear to corrode in about the same proportion. In the discussion Mr. White (the Chief Constructor of the Navy) drew attention to the question of cost, as affecting the application of materials in practice, and with nickel at £224 a ton, or £56 as the cost of the nickel in a ton of 25 per cent. nickel steel, it is a consideration.

The next paper, on the manufacture of basic open-hearth steel, by Mr. J. H. Darby, also gave rise to an important discussion. From the paper and discussion it may be inferred that the basic steel industry has not made so much progress in this country as it has done in Germany. This may be due to the circumstance that German ores are mainly phosphoric in character (Mr. Thielen, who spoke as to his experience in Germany, stating that of the steel now produced in the Siemens furnace in Germany 70 or 80 per cent. was produced in the Siemens basic furnace), or to the "Batho type" of furnace used in this country being inapplicable to steel-making, an opinion expressed as well by the author of the paper as by speakers who followed him. Mr. Windsor Richards could not understand why they had gone away from the rectangular furnace of Sir William Siemens, and was pleased to say that since he had returned to it his difficulties had come to an end; whilst Mr. John Head, Mr. Frederick Siemens's representative, spoke of a new form of regenerative gas furnace, recently built and tried, which consumed about 50 per cent. less coal than the original regenerative gas furnace, and promised a paper on the subject for the autumn Paris meeting of the Institute.

A statistical paper on the progress made in the German iron industry since 1880 was read by Mr. R Schroedter.

One on the influence of copper on the tensile strength of steel was read by Messrs. E. J. Ball and A. Wingham, in which the authors state that from a general consideration of the results of their experiments it would seem that within certain limits copper does not prejudicially affect the mechanical properties of steel. In this they agree with a theory brought by Prof. Roberts-Austen before the Royal Society last year to the effect that small quantities of a metallic impurity exert a deleterious effect on a large mass of another metal only if the atomic volume of the impurity is greater than that of the metal in which it is hidden. Mr. Bauerman, in discussion, expressed the opinion that it was not the copper, but the sulphur which generally came with the copper, that was injurious to iron.

The papers on universal rolling-mills for the rolling of girders and cruciform sections, by Mr. H. Slack, and on the Thomasset testing-machine, by M. Gautier, were mainly of mechanical interest. M. A. Pourcel read a paper on the application of thermal chemistry to metallurgical reactions.

ROBERT STIRLING NEWALL, F.R.S.

OBSERVANT travellers by the Great Northern Scotch express may see, as it nears Newcastle, the low dome of an astronomical observatory on the eastern side of the line. It is a spot which will be memorable in the history of astronomy, and it marks the home of a man who combined the practical sagacity and inventive skill which have made England the first industrial nation in the world, with the love of science which must be added to these if it is to hold its place.

Mr. Newall, whose death we chronicled a fortnight ago, was a successful manufacturer. When he was still a young man, a friend who was studying mining in Saxony informed him that cables made of iron wires were largely used there, but that the process of making them was "unmechanical," and suggested that he should invent a machine for the purpose. This he did, and wire ropes of his construction are now used all over the world. From time to time he improved on the original design, and so lately as 1885 he devised a new machine by which the rope is made at one operation, the double process of first making the strands and then combining them being avoided.

His interest in his business was not, however, confined to the gradual development of his earlier patents. He was quick to see that wire rope might help in solving the difficulties which had to be overcome before submarine telegraphy was an accomplished fact.

Sir Charles Wheatstone had clearly conceived the possibility of electric communication between England and the Continent as early as 1837. In 1840 he gave evidence on the subject before a Committee of the House of Commons, and references were made to his suggestion in the public Press. His drawings and notes show, however, how difficult the problems of insulating and preserving the cables seemed to these early pioneers.

The insulation was attained by the use of gutta-percha—of which Mr. Newall received a portion of the first sample transmitted to this country—but the cumbrous devices at first suggested for protecting the outer covering of the cable were forgotten when Mr. Newall proposed that the "gutta-percha lines containing insulated wire should be surrounded with a strong wire rope" (pamphlet by Mr. R. McCalmont, dated September 19, 1850).

The first cable, laid between Dover and Cape Grisnez, in which this plan was not employed, broke after one day. The first successful cable, which was laid on September 25, 1851, by Mr. Crampton, was manufactured by Mr. Newall, and protected by wire.

The submergence of cables in seas deeper than the English Channel presented greater difficulties, and the Newall drum-brake, which was introduced in 1853, and afterwards for a time abandoned, has since been again employed, so that, as Mr. F. C. Webb stated at the Institute of Telegraph Engineers in 1876, "we have come back to the old drum-brake of Newall."

Mr. Newall took an active part in superintending the actual laying of many cables, and on these occasions he showed the qualities of a leader of men—cool in an emergency, confident in his own resources, and undismayed in disaster. "Gentlemen, it's over now; ye may go to bed," was his only remark when a cable broke involving a loss of many thousands of pounds.

During the Crimean War he laid a wire insulated in gutta-percha without sheathing of any kind from Varna to the Crimea. It was run out over the stern through hand leathers held by the cable men in turn. He formed one of the boat's crew that left to seek help for the passengers of the P. and O. steamship *Alma*, wrecked in 1859 in the Red Sea.

But, during this busy life, Mr. Newall never allowed his love of pure science to be crushed by the weight of the practical affairs in which he was engaged. The success of submarine telegraphy was due to no one individual only, but to Mr. Newall belongs the credit of inaugurating a new era in the construction of refracting telescopes. He had long wished to possess a refractor of large dimensions, and in the Exhibition of 1862 he discovered two large disks of crown and flint glass, manufactured by Mr. Chance, of Birmingham. He at once saw that his opportunity was come, secured the glass, and placed it in the hands of Mr. Cooke, of York.

As the result of his boldness in risking a very large sum on an experiment the success of which was most uncertain, Mr. Newall carried, at one bound, the diameter of the largest object-glass from 15 to 25 inches. His observatory was a spot to which the most distinguished astronomers journeyed, and to which Profs. Newcomb, Holden, and Alvan Clark came as a deputation from the other side of the Atlantic.

Mr. Newall's original idea was to mount the telescope in the Mauritius, and spend as much time as possible there himself. This plan has never been carried out, and the great Newall refractor has never yet had a fair chance under the adverse skies of Newcastle. Almost his last act was to offer it as a gift to the University of Cambridge, and it is to be hoped that it may there add to the high scientific reputation that University has won.

To have established a new industry, to have taken an active part in securing a triumph of applied science which will modify the history of the world, and to have led the way in the development of the refracting telescope, is a record of achievement to which few attain, but which does bare justice to the life-work of Robert Stirling Newall.

NOTES.

THE Report of the Royal Commission appointed to consider the expediency of establishing a Teaching University for London, has been laid on the table of the House of Commons, and the Blue-book may be expected in the course of the next week. The Commissioners are agreed—first, that the petition of the Royal Colleges of Physicians and Surgeons to be authorized to grant degrees in medicine should not be entertained; secondly, that it is desirable that London should have a Teaching University. On the third point—whether a charter shall be granted to the associated Colleges of King's and University, constituting these Colleges the Teaching University of London—the Commission are divided. The three Commissioners connected with the teaching profession (Sir William Thomson, Prof. Stokes, and Mr. Welldon), are in favour of it; the three lawyers (Lord Selborne, Sir James Hannen, and Dr. Ball), are opposed to it. The Report ends with a request that this question be referred back to the Commission for their further consideration, in order that they may determine whether it is not possible to devise a scheme of common action between the two Colleges and the existing University of London.

PROF. STOKES will deliver the Rede Lecture on Wednesday, June 12, at 2 p.m., in the Senate House, Cambridge, the subject being, "Some Effects of the Action of Light on Ponderable Matter."

THE Museums and Lecture Rooms Syndicate, Cambridge, have been authorized to have quantities taken out and tenders invited for the proposed Anatomical and Physiological Buildings, in three distinct blocks.

MRS. DE LA RUE has presented to the Royal Institution the philosophical apparatus of the late Dr. Warren de la Rue. A fine portrait of Sir Humphry Davy has been presented to the same Institution by Mr. James Young, grandson of the late Dr. James Young, F.R.S., of Kelly, the former owner of the portrait.

THE Swedish Government has decided to send a man-of-war to New York to bring home the body of Captain Ericsson, who expressed a strong desire to be buried at Långbanshyttan, in Vermeland, the place of his birth. In his will no directions are given as to the disposal of his valuable collection of models, but Swedish journals state that the executors will present them to the Smithsonian Institution.

THE last mail from Bombay brings news of the formal opening, by Lord Reay, of the Jubilee Technical Institute in that city. The *Times of India*, commenting on this event, says it forms a notable landmark in the educational history of Bombay. That the Institute meets a public want is shown by the circumstance that it already numbers two hundred and forty students, while nearly half as many are awaiting nomination. The origin of the Institute is this. When Lord Ripon was about to leave India, a movement was set on foot to signalize his Viceroyalty by a memorial of some kind, and subscriptions were collected for the purpose. Soon after Lord Reay's arrival in Bombay there arose suggestions for the formation of a technical school. The Government in January 1887 promised a grant of 25,000 rupees annually, and recommended to the Municipal Corporation of Bombay that 80,000 rupees which they proposed to devote to commemorating the Jubilee of the Queen's reign should be devoted to the founding of a technical institute. The other funds were amalgamated with this, and a Board of management was formed; but still the funds were found insufficient, until at last the munificence of Sir Dinshaw Petit came to the rescue. He presented the Board with a noble building, and work began at once, and the formal official opening took place recently, although, in fact, the Institute has been open for several months. The immediate and signal success of the Institute Lord Reay attributes in no small measure to the fact that in starting the movement its originators did not allow themselves to yield to the demand for a programme.

THE Upsala University and the Swedish Geographical Society have sent Dr. Carl Forsstrand to study the marine fauna of the West Indian Islands during the present summer.

THE Indian papers report the death from cholera, at Rangoon, of Dr. Robert Romanes, Professor of Science in the Rangoon College, and Chemical Examiner to the Burmah Government.

IN the horticultural part of the Paris Exhibition there are some splendid beds of Darwin tulips in full bloom. The flowers are magnificent, and a *sergent de ville* keeps watch over them—an unusual proceeding in France, where flowers are never in ordinary circumstances stolen from public gardens. Unfortunately the presence of an unusual number of foreigners makes this precaution necessary. In the same part there is a very curious exhibit of Japanese horticulture. It consists of a number of specimens of dwarfed trees—trees which are usually tall, but in the present case hardly attain the height of 2 or 3 feet. This exhibit excites much interest among gardeners.

ZOOLOGISTS will be interested in the exhibit of the Principality of Monaco at the Paris Exhibition, as all the implements used by the Prince in his dredging experiments are to be shown, with numerous specimens of deep-sea fauna. The exhibit of the results of the *Talisman* researches will unfortunately be scanty.

LAST week, Mr. Ralph Moore, Inspector of Mines for the Eastern District of Scotland, on his retirement from that post, which he has held for twenty-seven years, received a farewell present from a number of gentlemen connected with the Scottish coal and iron trades. In thanking the donors, Mr. Moore gave some interesting details of the improvement in mining appliances since he first was a colliery manager, forty-eight years ago. At that date, he said, there were cages at two or three collieries in the county of Edinburgh, but there was none in Lanarkshire. The coals were all drawn in corbes. A few years after, there was not a single colliery without them. Pug engines were first introduced about 1845. Ventilating furnaces were of the most primitive description. Fans were unknown. The first fan in Scotland was put up in 1868; now there were hundreds, and scarcely anyone thought of doing without a fan. The amount of ventilation in a colliery was from 8000 or 10,000 down to as low as 1000 cubic feet per minute, and now there were some collieries in the district with 250,000 cubic feet per minute. Last year he made the calculation that eight tons of air were sent into the mines for every ton of coals extracted. Wire ropes were not in use at the time of which he spoke; now there was nothing else. Underground mechanical haulage was practically unknown; now it was universal. Many large collieries had only one shaft, now all had two. A coal-owner putting out 100,000 tons a year was a large coal-owner. There were coal-owners now putting out over 600,000 annually. As a consequence of all these improvements, the output of minerals in the district, which in 1856 was 4,500,000 tons, was now 17,000,000 tons, and the death-rate, which in 1853 was one for every 250 persons employed, is now about one in 800.

IN connection with the Congress of German Anthropological Societies, which is to meet this year at Vienna, a large exhibition of prehistoric objects is being formed. All the smaller public collections and the most important private ones of Austria will be represented.

SIR W. BRANDFORD GRIFFITH, Governor of the Gold Coast, has reported to Lord Knutsford the occurrence of a smart shock of earthquake at Accra on April 5, at 12.2 noon. The seismic wave seemed to run from south to north, and was felt at Aburi, twenty-six miles to the northward of Accra. Sir W. B. Griffith had not heard of any serious damage being caused in the colony, nor, so far as he could hear, was the earthquake felt at sea or at Addah. Christiansborg Castle, the Government House at Accra, was once laid in ruins by an earthquake.

EARTHQUAKES still continue in the neighbourhood of Vyernyi in Turkestan. On February 19, at 3 p.m., an earth-tremor was felt after a fortnight of absolute rest. The shock was quite isolated, and lasted but a few seconds. Another slight shock was felt during the night, at 2 a.m. On February 25, at 11 a.m., a noise like that of a discharge of a battery of guns was heard, and the soil was set in motion for about three seconds. Many houses cracked, but there was no loss of life.

La Nature of April 27 contains a representation, by photolithography, of an interesting synoptic table of weather prediction, by MM. Plumandon and Colomès, whereby anyone may find mechanically the probable weather, by observing the direction of the wind, as based upon fourteen years' observations at the Puy-de-Dôme Observatory. The table from which the representation is reduced, is printed in six colours, and is divided into eight sectors corresponding to the principal directions of the wind, and comprising 216 weather conditions. A movable indicator, with three arms, works upon a pivot; one arm being moved to represent the wind direction as shown by the clouds or a good wind-vane, the others then point to the region of lowest barometer, and to the probable weather, indicated by one of the cases referred to. These conditions are contained in a few words, and differ for each season of the year, and for different states of the barometer, *e.g.* high, low, &c. The principle involved is merely an application of the rule known as Buys Ballot's law: "Stand with your back to the wind, and the barometer will be lower on your left hand than on your right," combined with the experience gained in weather prediction during the last thirty years. A card somewhat similar in principle was published some years ago by the late F. Pastorelli. Persons unable to consult daily weather charts may find the diagram very useful.

IN a private letter recently received from Dr. Macgregor, the Governor of British Guinea, an interesting account of his trip in the *Hygeia* through the Louisiade Archipelago and the adjacent groups of islands is given. He found them, he says, all thickly inhabited, the natives being in thousands, and in many cases very wild—so wild, in fact, that he thinks it probable they had never seen a white man before. On some of the islands he found hot mud-springs, some of them being strongly impregnated with sulphur. Gold was found on many of the islands, but in no instance was it in payable quantities.

ACCORDING to *Allen's Indian Mail*, the Madras Museum now possesses the skeleton of the largest elephant ever killed in India. This elephant was the source of great terror to the inhabitants of South Arcot, by whom it was killed and buried. The Museum authorities despatched a taxidermist to the spot to exhume the bones and transfer them to Madras. The skeleton is exactly 10 feet 6 inches in height, being 8 inches higher than the highest hitherto measured in the flesh by Mr. Sanderson.

MR. LESTER WARD has recently claimed an American origin for the entire genus Platanus, of which the plane and the sycamore are the best-known species. It occurs abundantly, however, in these isles, in the Lower Eocenes of Mull, Reading, and the Middle Eocene of Lough Neagh, the former being probably at least as old as the beds in which it makes its earliest appearance in America. It probably came into existence in the Old World in late Cretaceous times.

DR. MARION describes, in the *Annales des Sciences Géologiques*, a new conifer, having the foliage of Araucaria with the cones of Dammara, and therefore an essentially Australasian type, which only became extinct in France in the Miocene. The material is so perfect and ample that very little more would remain to be learnt about it, were it still living. The same, or a nearly allied, species abounded in the Isle of Wight in the Oligocene. In outward form the tree must have resembled Cryptomeria.

THE May number of the *Kew Bulletin* opens with an interesting account (with plate) of the Persian dye plant *Zalil*, prepared by Sir Joseph Hooker for the April number of the *Botanical Magazine*. This is followed by an account of Tasmanian woods, some curious details as to lily flowers and bulbs used as food, a paper on Pu-êrh tea, an account (with plate) of the short-podded yam-beam, and a list of the staffs of the Royal

Gardens, Kew, and of botanical departments and establishments at home, in India, and in the Colonies, in correspondence with Kew.

IN his Report for 1888, just issued, the librarian of the Mitchell Library, Glasgow, notes, for the third year in succession, a decrease in the number of volumes issued to readers. This is believed to be mainly due to the fact that the rooms are not nearly large enough to provide accommodation for those who wish to use the library. Even now, notwithstanding the decrease of attendance, the rooms are often inconveniently crowded. It seems strange that in a wealthy and intelligent city like Glasgow there should be the slightest difficulty about the provision of a proper building for so good a collection of books—a collection which, according to the librarian, "is becoming year by year richer in all departments of literature, better fitted to supply the wants of every student and every reader."

THE Burton-on-Trent Natural History and Archæological Society have begun to issue "Transactions"; and if we may judge from the first volume, which we have just received, succeeding volumes are likely to contain a good deal of interesting work. The most important paper in the present volume is a Report, by Mr. John Heron, on certain explorations carried on at Staplehill in 1881, under the auspices of the Society. In the course of these explorations the remains of upwards of thirty-six human bodies were found, accompanied in some cases by personal ornaments, small iron knives, or weapons of a kind which showed that the ground had been a burial-place of the English in pagan times. The various "finds" are clearly described by Mr. Heron, whose paper is admirably illustrated by a frontispiece and ten plates.

THE third chapter of the revised edition of Dr. Elias Loomis's "Contributions to Meteorology" has been issued. In this chapter the author deals with the mean annual rainfall for different countries of the globe; describes the conditions favourable, and the conditions unfavourable, to rainfall; examines individual cases of rainfall in the United States, in Europe, and over the Atlantic Ocean; and defines the areas of low pressure without rain. Many valuable plates accompany the text.

THE May number of *Himmel und Erde* (Berlin) opens with an interesting description of the Lick Observatory, and an account of its foundation by the Director, Prof. Holden. The article is illustrated by a view of the giant refractor and the interior of the Observatory, the presence of three of the observers serving to give an idea of the immense size of the instrument. Dr. Mohn continues his account of the Norwegian North Sea Expedition, and Dr. Wagner concludes his article on the Krakatão eruption. Other articles and astronomical data for the month are also given.

THE new number of the *Folk-lore Journal* (vol. vii. part 2) contains an interesting paper, by Mr. John Abercromby, on the beliefs and religious ceremonies of the Mordvins, a people of Finnish descent inhabiting parts of Central Russia, who were pagans up to the beginning of the present century. The paper gives their conception of the Deity, a list of the various objects of worship, their account of the creation and the fall of man, and descriptions of their feasts and sacrifices. The paper is one of considerable length. Mr. Edward Clodd follows up his recent paper on "The Philosophy of Punchkin" by a similar one called "The Philosophy of Rumpelstiltskin," the latter being a generic title derived from the character in Grimm's well-known *Märchen*. An interesting bibliography of variants of the tale is appended. Students of folk-lore anxious to aid the Society by practical work will be glad to have their attention attracted to the appeal of the Council for volunteers to tabulate certain works which are mentioned, the method of tabulation being shown at the end.

MESSRS. SMITH, ELDER, AND CO. have issued a new edition of "Wild Life in a Southern County," one of the finest of the late Mr. Richard Jefferies's writings.

AT a recent meeting of the Linnean Society of New York City, Dr. G. B. Grinnell read an instructive paper upon the Rocky Mountain goat (*Mazama montana*). The limits of the range of this animal have never been fully defined by any one writer. It is a mammal belonging to the Arctic fauna, and only found among the high and rugged mountains of the Rockies and Coast Range, where the snow lies all the year. The centre of its abundance seems to be in Western Montana, Idaho and Washington Territories, and British Columbia, and it has been found from about latitude 44° to about latitude 65°; its southernmost records being on the highest peaks of the Sierra Nevada, near Mount Whitney. This goat is in no immediate danger of extermination, as it inhabits the most inaccessible localities, and has few natural enemies.

URIC ACID has been synthesized by Drs. Behrend and Roosen, of Leipzig, in a manner which completely settles the question of its constitution. A few months ago a synthesis of this important natural compound was effected by Horbaczewski, by fusing together glycocine, $CH_2.NH_2.COOH$, and urea, $CO\langle{}^{NH_2}_{NH_2}$. High temperature reactions, however, are never satisfactory as indicating the constitution of organic compounds, inasmuch as there is always a possibility of inter-molecular change. Hence a new mode of synthesis at lower temperatures has been devised by the Leipzig chemists, and carried out in an admirable manner, every stage being most critically investigated so as to be absolutely certain of the constitution of the intermediate compounds. The process consists of seven stages:—(1) The substances started with are aceto-acetic ether, $CH_3.CO.CH_2.COOC_2H_5$, and urea, $CO\langle{}^{NH_2}_{NH_2}$. These two compounds combine together with elimination of water, forming an ether of crotonic acid in which one of the hydrogen atoms is replaced by the radical of urea,

$$\begin{array}{l} \qquad\qquad\quad CH_3 \\ \qquad\qquad\quad | \\ NH_2.CO.NH—C=CH—COOC_2H_5 \end{array}$$

(2) This substance on saponification with caustic potash yields the potassium salt of the corresponding acid. The free acid itself readily splits off water, forming the anhydride,

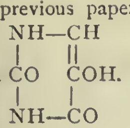
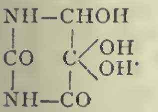
$$\begin{array}{lll} NH & — C & — CH_3 \\ | & \| & \\ CO & CH & \\ | & | & \\ NH & — CO & \end{array}$$

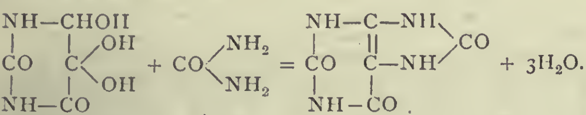
, methyl uracil, as it is termed. (3) On treatment with fuming nitric acid, the CH_3 of methyl uracil becomes oxidized to the acid radical, COOH, a nitro-group, NO_2, being simultaneously introduced,

$$\begin{array}{lll} NH & — C & — COOH \\ | & \| & \\ CO & C & — NO_2 \\ | & | & \\ NH & — CO & \end{array}$$

. (4) On boiling this nitro acid with water, a molecule of carbonic anhydride is eliminated, leaving a substance termed nitro-uracil,

$$\begin{array}{lll} NH & — CH & \\ | & \| & \\ CO & C & — NO_2 \\ | & | & \\ NH & — CO & \end{array}$$

. (5) On reduction with zinc and hydrochloric acid, nitro-uracil yields iso-barbituric acid—a compound which has been shown in a previous paper of Dr. Behrend's to possess the constitution  (6) By oxidation of iso-barbituric acid with bromine water another acid is obtained, which is found to be isomeric with dialuric acid, but differs entirely from that acid in properties; it is therefore termed iso-dialuric acid. From its reactions it is shown to correspond to the constitution  It crystallizes in long rhombic prisms containing a molecule of water of crystallization, which it loses at 100° C. The yield is very good, 80 per cent. or more of the theoretical. (7) It now only remains to mix this iso-dialuric acid with one equivalent of urea and six equivalents of sulphuric acid, the latter to take up three molecules of water which are eliminated in the reaction between the two former substances. The reaction is complete in the cold in twenty-four hours, or in five minutes if the mixture is gently warmed upon a water-bath. On cooling and adding water, uric acid is precipitated in small crystals, which, on purification, exactly resemble those of natural uric acid. The equation is very readily understood, there being a simple combination of iso-dialuric acid and urea with formation of uric acid and elimination of three molecules of water—



Iso-dialuric acid. Urea. Uric acid.

Hence the formula of Medicus and Fischer for uric acid may now be considered as finally proved.

THE additions to the Zoological Society's Gardens during the past week include a Purple-faced Monkey (*Semnopithecus leucoprymnus*) from Ceylon, presented by Mr. J. H. Taylor; a Vervet Monkey (*Cercopithecus lalandii* ♂) from South Africa, presented by Dr. W. K. Sibley; an Otter (*Lutra vulgaris*) from Cornwall, presented by Mr. Basset; a Long-eared Owl (*Asio otus*), British, presented by the Hon. Eric Thesiger; a Herring Gull (*Larus argentatus*), British, presented by Mrs. Gainsford; a Yellow-billed Amazon (*Chrysotis panamensis*) from Panama, presented by Lord William Cecil; two Common Kestrels (*Tinnunculus alaudarius*), captured at sea, presented by Captain Janes; two Common Rheas (*Rhea americana*, juv.) from Uruguay, presented by Mr. J. D. Kennedy; a Black Swan (*Cygnus atratus* ♂) from Australia, presented by Mrs. Siemens; a Long-eared Owl (*Asio otus*), British, presented by the Rev. F. Hopkins; two Natterjack Toads (*Bufo calamita*), British, presented by Master H. Millward; two Natterjack Toads (*Bufo calamita*), British, presented by Master A. Smith; a Bonte-bok (*Alcelaphus pygargus* ♂) from South Africa, deposited; a Squacco Heron (*Ardea railoides*) from South Europe, three Japanese Teal (*Querquedula formosa* ♂ ♀ ♀), from North-East Asia, an Amherst Pheasant (*Thaumalea amherstiæ* ♂), from Szechuen, China, purchased; two Moor Harriers (*Circus maurus*) from South Africa, received in exchange.

OUR ASTRONOMICAL COLUMN.

THE RESIDUALS OF MERCURY.—In a recent discussion of the perturbations of Mercury (*Astronomical Journal*, No. 191, April 15, 1889), Mr. O. T. Sherman has arrived at some important and highly suggestive results relating to the residuals. His method of determining these appeared in No. 173 of the *Astronomical Journal*, and this process has been employed in obtaining the data given in the article referred to. The values arrived at show a remarkable relation to the heliocentric latitude of the planet, the maximum effect being nearer the solar equator, and the effect decreasing as the latitude increases. Since the lower latitudes correspond to maximum and the higher ones to minimum solar activity, the apparent connection of the disturbances of the planet with solar phenomena should also bear some relation to the sun-spot period, and Mr. Sherman gives figures to show that this is the case. The chief disturbances occur in the years when the sun-spots are increasing in frequency, and it is pointed out that this result is in strict accordance with the retardations of Encke's Comet during perihelion passage.

It is further stated that "the forces deflecting the planet are sunward when the planet is in that part of space towards which the sun is travelling, and away from the sun when the planet follows in his path." This, taken in conjunction with the disturbances of Encke's Comet, seems to Mr. Sherman "to indicate a considerable amount of matter coming to the sun from space. If so, its place of meeting with the matter coming from the sun should abound in collisions, and display local spectra showing bright lines. Our knowledge of the zodiacal light is fully in accord with such a supposition."

If the more detailed investigations of the residuals, which it is intended to make when more observations have been collected, confirm the results already obtained, we may look for a considerable advance of our knowledge, especially of the nature of the solar surroundings. Already the residuals clearly admit of explanation by supposing that the sun, with its meteoritic surroundings, in the form of the corona and the zodiacal light, is moving with considerable velocity through a meteoritic plenum. In that case the planet would encounter most meteorites when on the advancing side of the sun, and it would obviously be more retarded there than elsewhere.

The apparent relation to the sun-spot period is of great interest in connection with the meteoritic theory of the formation of sun-spots. According to this theory, there should be most meteorites in the solar surroundings at maximum spot period, and greater disturbances of the planet at that period would therefore be expected. The collisions between the two sets of meteorites would further produce the spectroscopic phenomena associated with the zodiacal light—namely, the appearance of a line near wave-length 558, which has been ascribed to manganese. It seems probable that the variability of this spectrum which has been suspected by Mr. Sherman (letter to Mr. Lockyer, quoted in Roy. Soc. Proc., vol. xlv. p. 248) may also subsequently be shown to be connected with the sun-spot period.

RIGHT ASCENSIONS OF NORTH CIRCUMPOLAR STARS.—Prof. T. H. Safford, Field Memorial Professor of Astronomy at Williams College, Mass., has just published a very useful piece of work in the shape of a Catalogue of North Polar Stars. This Catalogue, which is a first instalment of a more extensive one, the observations for which are now in progress, has been constructed by Prof. Safford in order to strengthen what he felt to be the weak point of all the standard Catalogues, viz. the right ascensions of Polar stars. It was also a consideration with him that it would be easier to take account of instrumental corrections if a more extended list of Polars were generally used than has been the custom. These stars are also of importance in the study of proper motions, since their early observations are accurate.

The observations for this Catalogue were made at the Field Memorial Observatory, and not at the Hopkins Observatory of Williams College, and the meridian circle with which they were made was a fine one of $4\frac{1}{2}$ inches (French) aperture, by Repsold. The observations were made at first by eye and ear, but a fillet chronograph was used in 1887 and 1888. Prof. Safford's intention throughout was to make his Catalogue a differential one; the stars he has relied upon for his instrumental corrections, being those of Publication 14 of the Astronomische Gesellschaft, which lie within 10° of the Pole. Besides the catalogue itself, which contains 261 stars, of which just 200 are within 10° of the Pole, a very important part of the work is the discussion of the right ascensions, with a view to clearing up certain points as to mode of observation, as well as to find the weights and systematic corrections necessary for combining this series with others. The result of this discussion is to show that it tends to greater accuracy to base a catalogue of Polar R.A.'s on standard places in all hours of right ascension rather than on double transits alone; that the eye-and-ear method should be used as the standard only near the Pole; and that a thorough comparison of it with the chronographic method through a wide range of magnitude and declination is desirable; that modern meridian instruments are subject to irregular small changes of position which are not direct functions of temperature; and that, therefore, it is well not to trust the instrumental zero points for more than two hours without re-determining the most essential.

Prof. Safford is at work on a paper, now well advanced, on the proper motions of the stars within 10° of the Pole, and he hopes shortly to complete the comparison of the chronographic and eye-and-ear methods which the present discussion had shown him to be needed.

TWO REMARKABLE SOLAR ERUPTIONS.—Father Jules Fényi, of the Kalocsa Observatory, records, in a note to the Paris Academy of Sciences, his observation of two remarkable solar eruptions which he observed on September 5 and September 6, 1888. Both eruptions would have been remarkable had they occurred at a time of maximum activity; but, coming as they did nearly at dead minimum, they stand out as most unusual. The first prominence was seen to rise from a height of 25″, as seen at 6h. 6m. (Kalocsa M.T.), to 151″·4 at 6h. 19m., its speed of movement attaining at one time 171 kilometres per second. A number of brilliant metallic lines were seen, some so bright that, with a wide slit, they showed as a small prominence, reaching 19″ in height on 1474 K and 15″ on the D lines. The second eruption was seen eighteen hours later, on September 6, at 11h. 45m., and was even more violent. In 6½ minutes it mounted from 37″ to 158″, with a speed at one time of 296·8 kilometres per second. It was of dazzling brilliance whilst it lasted, but passed away in about 14 minutes. The two eruptions were nearly but not quite in the same heliographic latitude. The first was on the east limb in S. lat. 18°; the other was distant some 4½°, and, as the base of each was about 3° in length, they could not have overlapped, and if connected in origin, must have sprung from a deep-seated source.

COMET 1889 *b* (BARNARD, MARCH 31).—This object is now too near the sun for observation, but accepting the elements of its orbit as hitherto determined, it will not travel far from its present position for some time to come. Dr. Krueger gives its position for Berlin midnight (*Astr. Nach.*, No. 2893) for the end of May and beginning of July as under, but with reserve from the uncertainty of the elements:—

1889.	R.A. h. m. s.	Decl. ° ′	Log Δ.	Brightness.
May 28	... 5 6 52	... 14 13·1 N.	... 0·5099	... 0·71
July 3	... 5 9 8	... 12 19 0 N.	... 0·4944	... 0·76

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 MAY 19–25.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 19

Sun rises, 4h. 4m.; souths, 11h. 56m. 15·8s.; daily increase of southing, 2·8s.; sets, 19h. 48m.: right asc. on meridian, 3h. 45·6m.; decl. 19° 52′ N. Sidereal Time at Sunset, 11h. 39m.

Moon (at Last Quarter on May 21, 22h.) rises, 23h. 50m.*; souths, 3h. 50m.; sets, 7h. 53m.: right asc. on meridian, 19h. 37·9m.; decl. 22° 25′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	4 57 ...	13 29 .	22 1 ...	5 18·2 ..	25 27 N.
Venus ...	3 0 ...	10 12 ..	17 24 ...	2 1·5 ...	13 8 N.
Mars ...	4 25 ..	12 30 ...	20 35 ...	4 19·2 ...	21 53 N.
Jupiter ...	22 48*...	2 44 ...	6 40 ...	18 32·1 ...	23 0 S.
Saturn ...	9 42 ...	17 19 ...	0 56*...	9 9·3 ...	17 35 N.
Uranus ...	15 48 ...	21 18 ...	2 48*...	13 9·0 ...	6 38 S.
Neptune..	4 24 ..	12 11 ...	19 58 ...	4 0·4 ...	18 59 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

May.	h.	
20 ...	12 ...	Venus stationary.
23 ...	3 ...	Neptune in conjunction with the Sun.
24 ...	19 ...	Mercury at greatest elongation from the Sun, 23° east.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m	
U Cephei ...	... 0 52·5	... 81 17 N.	... May 21,	0 50	*m*
R Persei ...	... 3 23·0	... 35 18 N.	... ,, 19,		*M*
U Monocerotis ...	7 25·5	... 9 33 S.	... ,, 21,		*M*
S Leonis ...	... 11 5·1	... 6 4 N.	... ,, 22,		*M*
S Boötis ...	... 14 19·2	... 54 19 N.	... ,, 21,		*M*
R Boötis ...	... 14 32·3	... 27 13 N.	... ,, 23,		*m*
δ Libræ ...	... 14 55·1	... 8 5 S.	... ,, 20,	22 59	*m*
U Coronæ ...	... 15 13·7	... 32 3 N.	... ,, 19,	1 35	*m*
R Draconis ...	... 16 32·4	... 66 59 N.	... ,, 24,		*M*
U Ophiuchi...	... 17 10·9	... 1 20 N.	... ,, 22,	0 55	*m*
			,, 22,	21 3	*m*
T Herculis ...	... 18 4·9	... 31 0 N.	... ,, 24,		*M*
R Lyræ ...	... 18 52·0	... 43 48 N.	... ,, 21,		*m*
U Aquilæ ...	... 19 23·4	... 7 16 S.	... ,, 25,	2 0	*M*
η Aquilæ ...	... 19 46·8	... 0 43 N.	... ,, 21,	0 0	*m*
T Vulpeculæ	... 20 46·8	... 27 50 N.	... ,, 21,	22 0	*M*
T Cephei ...	... 21 8·1	... 68 2 N.	... ,, 19,		*M*
δ Cephei ...	... 22 25·1	... 57 51 N.	... ,, 25,	0 0	*M*

M signifies maximum; *m* minimum.

GEOGRAPHICAL NOTES.

IN the new number of *Petermann's Mitteilungen*, Dr. Rink describes the recent Danish researches in Greenland, especially those carried out in East Greenland under the leadership of Captain Holm. The aim of the expedition was mainly antiquarian and ethnological; at the same time the report of its work contains valuable observations on the geology, geography, and especially the glacial conditions of the region visited. In the first volume of the Report, the first chapter, by Prof. Steenstrup, is devoted to a discussion of the situation of Osterbygd. The second chapter contains the report of Captain Holm and Lieutenant Garde on the results of the expedition of 1883–85. The principal results may be thus summarized:—Graah's map of the east coast of Greenland has been corrected and completed; a map has been prepared of a part not previously surveyed, and now named Christian IX. Land; and, after sketches and information from the natives, the outline of the coast has been continued from 66° to 68½° N. lat. It was found that the country called after Christian IX. was inhabited by a branch of the Eskimo which, before the arrival of the expedition, had not been in contact with Europeans. Detailed observations have been made on their mode of life, their customs, language, legends, &c., and a large collection made of articles of ethnological interest. During the various journeys of the expedition, and especially in their winter quarters, systematic researches were made in the physical geography of the country. Geological and botanical observations were made and specimens collected along the east coast. It was found that the east coast of Greenland is not so inaccessible as has hitherto been supposed. The expedition explored the east coast as far to the north as it was at all likely Osterbygd could have been located, without discovering the least trace of buildings which were not of Eskimo origin, and without finding anything in the physiognomy, the customs, mode of life, or legends of the natives that could furnish the slightest ground for inferring former relations with Europeans. From this it is concluded that Osterbygd could not have been situated on the east coast of Greenland. The third chapter deals with the geography of Danish East Greenland, *i.e.* as far as 66° N. This part of the east coast is divided into five natural zones—(1) the most southerly part as far as Anarket; (2) from Anarket to Ikermiut; (3) from Ikermiut to Igdlolnarsuk; (4) from Igdlolnarsuk to Inigsalik; (5) the section which extends to the east of the last-named place. Zones 1, 3, and 5 have strong resemblances with each other, as also zones 2 and 4. The three first-mentioned zones are cut by deep fjords, crowned with lofty serrated mountains, never covered by the continental ice. Some places are characterized by a vegetation comparatively rich. Beneath the mountains there are, in general, numerous glaciers, which often descend to the fjords, and towards the interior is found a mountainous region filled with large local glaciers. Zones 2 and 4 have a different aspect. The country is very barren, and the continental ice descends almost directly to the sea, or to the edge of the fjords, only a few mountains or rounded groups of mountains emerging from the ice. Another characteristic of the east coast is the parallelism of most of the fjords in an E. ¾ S. direction, as compared with the south-west direction of the fjords on the west coast.

THE new number of the *Mitteilungen* also contains a map of the flora of Schleswig-Holstein, with accompanying text by Dr. Ernest Krause, and an account of a journey to the sources of the Tigris by Prof. Wimsch.

THE paper read at Monday's meeting of the Royal Geographical Society was by Mr. J. R. Werner, on his journeys up the Ngala and Aruwimi tributaries of the Congo. The Ngala enters the Congo a little south of 2° N. lat., coming from a generally north-east direction. A little above its junction with the Congo is a channel through which the waters of the latter flow into the Ngala. For a considerable distance the banks of the river are low, swampy, and forest-clad. Gradually hills appear, and latterly bluffs, between which the channel narrows considerably. In May of last year, Mr. Werner accompanied the steamer to the Aruwimi, which was taking the men to Major Barttelot's camp at Yambuya. He was surprised at the number of sand-banks on the lower river, and the difficulties of navigation. After passing the town of Mokulu, the whole character of the country seemed to change, the islands stood higher out of the water and were covered with forest, which was crowded with palms, the crowns of which looked very pretty above the trees. The high banks on either side were lined with villages, or rather the sites of former villages, for the Arabs had been raiding here, and the natives were now living under roughly put-up sheds of leaves and sticks; the conical huts described by Stanley had almost entirely disappeared, and during the time Mr. Werner was on this river he only saw six, four of which were inside Major Barttelot's camp at Yambuya, and the other two in the village of Irungu. On the high bluff on which Stanley had found the large town of Yambumba, there was not a single hut on the vast clearing where the town had been, while on the opposite bank of the river such of the natives as had not been killed or carried into slavery were living under sheds and awnings of sticks and palm-leaves. On this side of the river the bank was quite low, and offered a strange contrast to the precipitous bluff on which the town had formerly stood. Above Yambumba the Aruwimi runs between two ridges of low hills, which are covered with magnificent timber. There are no more villages on its banks until Yambuya is reached.

AFTER the reading of Mr. Werner's paper at the Geographical Society, there was a discussion on the letter from Mr. Stanley which was read at the previous meeting. In this discussion Sir F. De Winton, Sir Samuel Baker, Colonel Grant, Rev. Horace Waller, and others took part. Sir Samuel Baker's statement was of considerable geographical interest. Against Mr. Stanley's doubts, Sir Samuel maintained the accuracy of his original observations as to the southward extension of Lake Albert Nyanza. He pointed out that Mr. Stanley himself refers to the very marked decrease in the size of the lake in the last few years, a decrease quite analogous to that which has taken place in Lakes Tanganyika and Nyassa. This decrease has no doubt tended to diminish the southern extension of the lake, and bring to light the vast extent of Ambatch or Sud which Gessi and others refer to. Sir Samuel maintains, moreover, that it will most probably be found that the two lakes (Albert Nyanza and Muta Nzigé) are really one, and are known among the natives by one name. The region which lies between them on our maps has never been visited by any European explorer. Sir Samuel pointed out the vast importance to Egypt of a precise knowledge of the laws which govern the increase or decrease of water in the Albert Nyanza, which is really one of the great sources of supply for the regions on the lower river.

IN the May number of the *Scottish Geographical Magazine* will be found a very complete account of Samoa and its people by Dr. G. A. Turner, who has lived many years on the islands.

THE town Kara-kol, on Lake Issyk-kul, has received the official name of "Prjevalsk" in commemoration of the explorer of Central Asia.

A GEOGRAPHICAL expedition, under the two brothers Grum-Grzimailo, has lately started for the exploration of the Eastern Tian-Shan. On April 19 it had reached Tchardjui, on the Trans-Caspian Railway. Its aim is to connect the explorations of M. Potanin in North-Western Mongolia with those of Prjevalsky. One of the two brothers is already well known for his explorations of the Pamir.

THE Russian Geographical Society is sending out the following expeditions:—M. Vilkitzki, who has made pendulum-observations on Novaya Zemlya, will continue the same measurements in Central and South-Eastern Russia. M. Faussek is sent out to the shores of the White Sea in order to make zoogeographical explorations in the Kandalak Bay, as well as for observations upon the secular rising of the coasts of the White Sea. M. Andrusoff, whose interesting researches into the geological history of the Caspian Sea have attracted a good deal of attention, will continue the geological exploration of Daghestan and Kuban; and M. Kuznetsoff will continue in the Caucasus his work upon the geography of plants. M. Antonoff is sent out to the Transcaspian region for the study of the conditions of animal and vegetable life in the desert; and MM. A. P. Semenoff and Yaschenko will visit the same region for zoological and botanical researches. Of ethnographical expeditions that of M. Katanoff to North-Western Mongolia is worth noting. The investigation of the folk-lore of the White Russians (Byelorusses) will be continued by MM. Romanoff and Dobrovolsky.

THE expedition to Tibet, the departure of which was delayed by the death of Prjevalsky, is now at the town Prjevalsk (formerly Kara-kol), and it will start in a few days, *viâ* the Bedel Pass, to Kashgar. The original plan of reaching Lhassa has been abandoned, and the expedition will limit its explorations to Eastern Turkestan and North-Western Tibet. It is under the leadership of Colonel Pyevtsoff, who accompanied Prjevalsky in all his memorable journeys. It includes also two other travelling companions of Prjevalsky—MM. Roborovsky and Kozloff—and a geologist, M. Bogdanovitch, who is commissioned by the Russian Geographical Society.

THE ROYAL SOCIETY CONVERSAZIONE.

THE annual *conversazione*, held by the Royal Society on May 8, was in every way brilliantly successful. There was a numerous attendance, and the programme had been arranged with the greatest skill and care. We refer to some of the most novel and important objects exhibited. In addition to these, the results set forth in many recent papers to the Royal Society were illustrated by experiments.

Mr. C. V. Boys, F.R.S., exhibited:—(1) Portable Cavendish apparatus for demonstrating the attraction of gravitation. This apparatus differs only from the well-known apparatus of Cavendish in matters of detail. First, instead of the beam 6 feet long, carrying heavy weights, used by Cavendish, or half a metre long, used by Cornu, the beam consists of a piece of lead only 1 centimetre long, and this is inclosed in a round tube of metal, outside which the attracting weights are placed. This reduction of size has been rendered possible by the use of quartz threads, the production of which was shown two years ago. The advantages gained by the reduced dimensions are increased sensibility, and almost perfect elimination of temperature disturbances. The particular apparatus exhibited is designed to show the effect, and that it is the same from time to time, rather than to determine the constant of gravitation absolutely. By arranging the two attracting weights and the two ends of the attracted body at different levels, the deflection is nearly doubled.—(2) Experiment showing the insulation of quartz. A pair of gold leaves are supported by a short rod of quartz which has been melted and drawn out about three-quarters of an inch. The atmosphere is kept moist by a dish of water. Under these circumstances a glass insulating stem allows all the charge to escape in a second or two. With the quartz but little change is observed in four or five hours. The quartz may be dipped in water and put back in its place with the water upon it. It insulates apparently as well as before.—(3) Apparatus for testing the elasticity of fibres. One of these pieces of apparatus consists of a microscope cathetometer arranged vertically, and a gravity bob which is deflected by the vertical pull of the fibre on a side arm. The lower end of the fibre is made fast to a beam carried by the microscope. A scale, to which the upper end of the fibre is fixed, is viewed by the microscope, which thus shows the stretch of the thread; the pulling force is found by subtracting the stretch from the vertical movement of the microscope and multiplying by a constant previously found. The second piece of apparatus is used to measure the fatigue of fibres after torsion.

Results of experiments with working model of the tidal Seine, exhibited by Mr. L. F. Vernon Harcourt. These experiments were undertaken with the object of obtaining an indication of the effects which the various schemes proposed for the improvement of the estuary of the Seine, by the prolongation of the training walls below Berville, would have upon the estuary if carried out. After ascertaining, by experiments, that the former and present conditions of the Seine estuary could be reproduced in miniature in the model, the various schemes proposed were successively introduced in the model, with the results shown upon the diagrams exhibited. The method of working this model has since been applied to the model of another estuary, which may be seen in operation at 6 Queen Anne's Gate, Westminster.

Profs. A. W. Rücker, F.R.S., and T. E. Thorpe, F.R.S., exhibited maps to illustrate the direction and magnitude of the regional magnetic disturbing forces in the British Isles. The British Isles can be divided into a comparatively small number of districts, in each of which the horizontal disturbing forces tend towards centres or loci of attraction, which are also regions of large vertical force. The shaded portions of the maps are districts of high vertical force, and it will be seen that the arrows which represent the horizontal forces on the whole point towards them. In Scotland the forces indicated by the dotted arrows were deduced from data collected in 1857–58 by Mr. Welsh. The five principal lines towards which the magnetic disturbing forces in Great Britain converge are in the immediate neighbourhood of (1) the Caledonian Canal; (2) the basalt of the Western Isles; (3) the centre of the Scotch coal-field, in which basaltic crystalline rocks occur; (4) the line in South-East Yorkshire, in which the Jurassic and Liassic strata thin out, and passing thence to the Lakes; (5) the Palæozoic ridge between London and the South Wales coal-field. There are well-marked centres of attraction, (1) between Reading and Windsor, (2) near the Wash, which have been specially studied. The disturbance which culminates in the first extends from Kenilworth to the Channel, and from Salisbury to the North Sea. The well-known anomaly in the difference of the declinations at Greenwich and Kew is thus accounted for. The maps also afford indications of other subsidiary centres.

Captain H. Capel L. Holden, R.A., showed:—(1) Chronograph for measuring the velocity of projectiles and small periods of time. This chronograph, of which the latest form with Captain Holden's most recent improvements is exhibited, is of the gravity type, originally invented by M. Le Boulengé; since its first introduction it has been improved by Captain Bréger, of the French Marine Artillery. Broadly speaking, it consists of a heavy pillar, to which are affixed two electro-magnets (the circuits of which are arranged to be interrupted by the action of the body whose velocity it is required to measure) which can support two rods, the shorter one of which, in falling, strikes a trigger table and releases a knife, which marks the other as it falls. The time elapsing from the commencement of the fall of the short rod until the knife strikes the other rod is obtained mechanically by means of the instrument called the disjunctor, which breaks both of the separate circuits simultaneously: a commutator in connection with this disjunctor enables errors due to the circuits not being broken simultaneously to be detected and corrected for. When an interval of time occurs between the two circuits being broken, the mark made on the rod by the knife will be more or less above that made when the disjunctor is used, and the space between the two marks gives the means of ascertaining the time, since the rod falls under the influence of gravity. In ordinary use, the screens, where the interruption of the circuit takes place, are made of a continuous wire in circuit, each with its electro-magnet and battery, and these screens are broken by the passage of the projectile through them. The disjunctor reading is arranged so as to be adjustable by altering the height of the magnet, so that, the screens being a fixed distance apart, a scale can be engraved on the micrometer bar of velocities in feet per second, thus saving time and avoiding frequent calculation.—(2) Holden hydrometer. This is intended more especially for use in connection with secondary batteries, for observing the density of the acid during charge and discharge. It consists of two parts—the hydrometer-float and the scale. In use, the scale is clipped to the battery plates or to the side of the containing vessel, the point being pushed down until it just touches the liquid, and the reading is then taken from the top of the hydrometer stem on the ebonite scale. The range of density and the size of the divisions can be varied according to the requirements. The advantages claimed for this form over the ordinary type of hydrometer are: greater sensitiveness, more open scale, and increased legibility owing to the reading being above the level of the liquid and side of the cell, freedom from adherence to the plates or side of the vessel, and the ready correction for temperature by means of a sliding scale.

A model illustrating the formation of ocean currents, exhibited by Mr. A. W. Clayden. This is practically a map of the Atlantic in which the land surfaces are raised about half an inch above the portions occupied by the sea. The continents and larger islands are made of wood cut into the required shape, while the smaller islands are represented by pins or small pieces of sheet metal driven into the board which forms the basis of the whole. This raised map forms the bottom of a shallow tray which can be filled with water up to the level of the land surfaces, thereby obtaining a map (on Mercator's projection) in which the seas are represented by the surface of water. Underneath the tray a wind chest is fixed, and a number of tubes are brought up from it through the continents, and bent over so that the jets of air delivered from them may impinge upon the water. These jets are so arranged as to approximately reproduce on a small scale the actual circulation of the atmosphere as laid down on a chart of the prevalent winds for the year. Care is taken to have as few tubes as possible, and they are so placed as to hide the least possible amount of the sea. The strong and persistent trades are simulated by bringing the openings of the tubes near to the surface of the water, while the fitful and uncertain winds of northern latitudes are imitated by allowing the jet to be considerably dispersed before coming into contact with the water. A foot-blower is attached to supply the wind, and any movement of the water is rendered visible by scattering over it some Lycopodium powder. A few moments after the blast is turned on, the whole surface of the model sea is in motion. All the principal currents of the North Atlantic are shown, including the return current between the great equatorial currents, and the northward stream along the west coast of Greenland. If a narrow opening is made in the Isthmus of Panama all that happens is that some of the return stream round the Mosquito Bay and Gulf of Darien flows into the Pacific, leaving the North Atlantic practically unaffected. But if a large part of Central America is removed, almost the whole of the tropical water passes through the opening, and the currents from Baffin's Bay and the Arctic Ocean are drawn down to the Azores and the Canary Isles. There is an absence of evident connection between the slack water close to the New England coasts and the Labrador current, but the apparatus does not attempt to imitate differences of temperature or differences of rotational velocity, hence any effect due to either of those causes must necessarily be absent. All that is attempted is to demonstrate the connection between the prevalent winds and general oceanic circulation, by showing that nearly all the movements of the water are determined by the direction of the winds and the contours of the coasts.

Mr. James Pitkin exhibited:—(1) Pitkin and Niblett's fire-damp meter. By means of these instruments it is possible to detect and estimate the percentage of oxygen or hydrogen in mixtures of these gases. In its simplest form it consists of two ordinary cylindrical bulbed mercurial thermometers. These are mounted on a suitable base, and are then graduated off in the ordinary way to Fahrenheit or Centigrade scale. One tube registers the temperature of the mixed gases. The other, which is the gas indicator, has its bulb coated with one of those metals which when in a very finely divided state have the peculiar property of occluding and facilitating the chemical combination of certain gases. When placed in a gaseous mixture and during the combination of the gases due to the above property of the metal, a considerable amount of heat is developed. The heat generated thus produces a corresponding rise in the mercurial column. To read the instrument the difference between the two scale readings is taken, and then, by comparison with a table supplied with each instrument, the percentage of gas may be read off. In the case of fire-damp and air or coal-gas and air, the amount of heat developed appears to correspond approximately to the explosive activity of the mixed gases. A sliding scale may be fixed on the instrument, which can be graduated in terms of percentages of any particular gas.—(2) Pocket electric lamp. This lamp is constructed for astronomical and other scientific purposes where a steady and a safe light is occasionally required. Its total weight is 1 lb. 13 oz., and it gives a light of 1 candle-power for a period of six hours. Its charging current is 1 ampere at a potential of 5 volts for four hours.

A series of ancient wreaths and plant remains from the cemetery of Hawara, Egypt, exhibited by Mr. Percy E. Newberry, by permission of the Director of the Royal Gardens, Kew. These wreaths and plant remains were discovered last year by Mr. Flinders Petrie, in coffins of the Ptolemaic period, and date from about the first century before Christ. They are fully described by Mr. Percy E. Newberry, in Mr. W. M. Flinders Petrie's "Hawara, Biahmu, and Arsinoë," and were presented to Kew some few months since.

Gramme ring, rotating under the influence of the magnetism of the earth, exhibited by Mr. J. Wilson Swan. It is a motor of the type of the ordinary dynamo-electric machine, but without field magnets other than the north and south magnetic poles of the earth. The current passing in the ring is about half an ampere.

Preparations of the new element gnomium, recently discovered by Gerhard Krüss and F. W. Schmidt, of Munich, exhibited by Dr. Hugo Müller, F.R.S. Gnomium oxide; gnomium chloride (in aqueous solution); nickel from which the gnomium, which up to the present always accompanied it, has been separated; nickel oxide free from gnomium. Gnomium is a metallic element which, according to the discovery of Krüss and Schmidt, is always associated with cobalt and nickel, and consequently neither of these metals have up to the present been known in the pure state.

Illustrations of the new and the old astronomy, exhibited by Mr. Isaac Roberts. Among these was the photograph of the nebula 51 M. Canum Venaticorum; the original negative being shown under the microscope.

Mr. H. J. Chaney showed a hollow cylinder and sphere, used in the re-determination of the weight of a cubic inch of distilled water, 1889. $t = 62°$, B = 30 inches. One cubic inch = 252·286 grains.

Voltaic balance, exhibited by Dr. G. Gore, F.R.S. Used for measuring voltaic energy in chemical analysis; strength of aqueous solutions; effect of light and heat on aqueous solutions; detecting chemical changes in liquids and measuring their rates: detecting chemical compounds and their combining proportions; measuring losses of voltaic energy during chemical combination; measuring chemical energy. By means of it the influence of 1 part by weight of chlorine in 500,000 million parts by weight of water has been detected.

Films of metals and metallic oxides deposited by electric sparks, exhibited by Prof. W. N. Hartley, F.R.S.

Hair from the Yenisei Mammoth, obtained by F. Schmidt, of the Academy of Sciences, St. Petersburg, exhibited by Prof. G. H. Seeley, F.R.S.

Drawings illustrating the feeding of Scrobiculariæ, exhibited by Dr. H. C. Sorby, F.R.S. The feeding of Scrobiculariæ, as also of Tellinæ, is by actively taking in mud by the indraught syphon and afterwards discharging it by the same, unlike the quiet habit of most other Conchifera.

Mr. J. Young showed—(1) a cluster of nests of a species of Swift (Collocalia) taken in one of the Society Islands; (2) a specimen of *Pluvianellus sociabilis*, a plover obtained in South America, of which only two specimens (obtained fifty years ago) were previously known in Europe; (3) the tail of a Japanese barndoor cock, 11 feet long.

Mr. W. H. Preece, F.R.S., exhibited—(1) calcedonified tree-trunk, from Arizona, U.S.A.; (2) transverse, tangential, and radial microscopical sections of the wood, to illustrate the original vegetable structures and the mineralogical changes which have taken place during and subsequently to the silicification of the woody tissues.

Egyptian blue ("Vesterien") artificially prepared by Prof. F. Fouqué, of the Collège de France, Paris, exhibited by Prof. J. W. Judd, F.R.S. This substance is shown to have the formula CaO, CuO, 4SiO. It has been obtained, not only in a glassy form, but in crystals, which are remarkable for their intense pleochroism (dark blue to rose pink), as was shown in specimen under microscope. For comparison specimens of ancient objects (Scarabei and ornaments used in mosaic work) were exhibited by Mr. R. H. Soden Smith, to illustrate the method in which this blue enamel was employed by the Egyptians. Other specimens of antique ornaments glazed with the Egyptian blue, exhibited by Mr. John Evans, Treasurer of the Royal Society.

A revolving stage for the microscope, exhibited by Prof. R. J. Anderson.

Prof. H. Marshall Ward, F.R.S., exhibited various parasitic fungi, and specimens of diseased timber showing characteristic symptoms of injury caused by them. The chief of these are:—(1) piece of larch stem, affected with the "larch disease," and exhibiting the cups of *Peziza* (*Helotium*) *willkommii* on the cancerous cortex; (2) specimen of fructification of *Polyporus sulphureus*; (3) piece of larch timber attacked by *Polyporus sulphureus*, showing the characteristic symptoms of the injury; (4) piece of oak timber, exhibiting the characteristic symptoms of disease due to the ravages of *Stereum hirsutum*; (5) piece of oak attacked by *Thelephora perdix*, showing the very different mode of injury due to this fungus; (6) piece of spruce fir, attacked by the mycelium of *Trametes radiciperda*, and exhibiting the very characteristic dark spots which serve to diagnose the disease; (7) piece of pine injured by *Agaricus melleus*, and showing the very different symptoms which betray the presence of this fungus; (8) piece of deal with grey mycelium of *Merulius lacrymans*, causing the common "dry rot" of timber; and a similar piece of timber attacked by the white mycelium of *Polyporus vaporarius*, another and quite different fungus, which produces a form of "dry-rot"; (9) portion of pine stem infected with *Peridermium pini*, the Æcidium form of *Coleosporium senecionis*,—the other form of this parasite is found on various species of groundsel (it does much damage to the pines in some forests, producing so-called "cankers" as disastrous as those of the "larch disease"); (10) specimen of wheat infested by *Ustilago carbo* (*U. segetum*), showing the destruction of the ears by the fungus, the black spores of which completely occupy the interior of the grain; (11) specimen of grass attacked by *Epichloe typhina*, a destructive ascomycetous fungus which infests the flowering shoots of pasture grasses: (12) culture specimens of *Sclerotia* developed from species of *Botrytis*, which destroy certain garden plants. Microscopic preparations of these are also exhibited.

Models illustrating a cause of contortions of strata, exhibited by Dr. Charles Ricketts. To induce these flexures, dry and powdered clay of different colours is spread in consecutive layers in a trough, when by the access of water, the clay becomes plastic, sand is poured on some special part, its weight in the experiment being supplemented by extra pressure; this causes the heavier substance to subside into the plastic mass; at the same time the clay-beds are squeezed outwards, the layers underneath being formed into films still continuous with those at the sides, which are rendered considerably thicker than in their original state, and are curved into folds, representing on a small scale such as frequently occur in stratified rocks. The experiment so exactly coincides with natural phenomena that it is reasonable to expect it will afford a true explanation of a frequent cause of contortion, and also of cleavage of strata (see "On some Physical Changes in the Earth's Crust, Part 3," *Geological Magazine*, April 1889, p. 165).

Amorphophallus campanulatus, exhibited by the Director of the Royal Gardens, Kew.

New optical apparatus for lecture demonstration, invented and exhibited by Mr. Eric Stuart Bruce:—(1) Apparatus for projecting Crookes's radiometer in action on the screen, so as to render its effects visible to large audiences.—(2) "The electro-graphoscope." A striking method of showing the illusions produced by persistence of vision to large audiences. In this apparatus a narrow lathe of wood, about an inch wide, is made to revolve rapidly by means of an electric motor, the effect being an almost invisible haze, but when the revolving lathe is placed in the path of the rays of light proceeding from an oxyhydrogen lantern, in which there is a transparent picture or photograph, the image is apparently cast upon the air, in the case of a statue giving the effect of bold relief. In reality minute portions only of the image are cast upon the revolving plane, in such rapid succession that they are united into the perfect whole by the retentive action of the retina of the human eye.

Mr. Eadweard Muybridge exhibited projections by the electric lantern of automatic electro-photographs, exposed at regulated intervals of time, illustrating the consecutive phases of bipedal locomotion, as synchronously viewed from two or more points of sight.

SCIENTIFIC SERIALS.

American Journal of Science, May.—The electrical resistance of stressed glass, by Carl Barus. Following up Warburg's experiments, which have thrown so much new light on the thermal relations of the resistance of glass, the author here deals specially with the effects of stress on electrolyzing glass kept as nearly as possible at different constant temperatures between 100° and 360°. He finds generally that a solid electrolyte like glass is a better conductor of electricity when in a state of strain or torsion than when free from strain. The influence of temperature in changing the value of the electrolytic effect of stress is not marked; the same pull per unit section does not apparently increase the conductivity of glass more at 350° than at 100°, if indeed it increases it as much.—On the formation of siliceous sinter by the vegetation of thermal springs, by Walter Harvey Weed. These researches on the origin of the deposits of siliceous sinter found in the basins of the Yellowstone National Park make it evident that such deposits are largely formed by the vegetation of the hot spring waters. Waters too poor in silica to form sinter deposits by any other cause may be accompanied by beds of siliceous sinter formed by plant life; the extent and thickness of these deposits establish the importance of this form of life as a geological agent.—Marine shells and fragments of shells in the Till near Boston, by Warren Upham. These fossils, occurring in drift deposits near Boston, are usually regarded as evidence of a marine submergence within the Pleistocene or Quaternary period. But Mr. Upham's observations made last year show that they were transported from the bed of the sea on the north by the ice-sheet in the same manner as the materials of the drift have been carried southwards and often deposited at higher elevations than the localities from which they were brought. Hence these shells afford no proof of the former presence of the sea at the level where they are now found.—A platiniferous nickel ore from Canada, by F. W. Clarke and Charles Catlett. The careful analysis here made of these ores from the mines at Sudbury, Ontario, places beyond all doubt the presence of platinum in appreciable quantities. It probably exists in the ore as sperrylite, though this point has not yet been determined.—Stratigraphic position of the Olenellus fauna in North America and Europe, by Chas. D. Walcott. The general result of these researches is to remove the Olenellus fauna both in the Old and New World from the Middle Cambrian to the base of the whole Cambrian system. The paper, which is not concluded, gives full tables of this fauna, with its areas of geographical distribution east and west of the North Atlantic.—Earthquakes in California, by Edward S. Holden. The statistics of seismic disturbances in this region with incidental remarks are brought down to the end of the year 1888.—Chemical action between solids, by William Hallock. In his recent note on a new method of forming alloys, the author undertook to carry out some additional experiments, the results of which are here given. He infers generally that chemical action may take place wherever the products are liquid or gaseous, even though the reagents are solid, with perhaps the added condition that one or both reagents be soluble in the liquid produced.

Revue d'Anthropologie, troisième série, tome iv., deux^{e}. fasc. (Paris, 1889).—On the colour of the eyes and hair of the Aïnos, by M. Lefèvre. These notes were drawn up at the suggestion of Dr. Colignon, while the author was acting as Professor at the Military College of Japan. The principal point commended to his notice was to determine whether there was any foundation for the statement, made by various travellers, that many of the Aïnos present the anomalous condition, that while the hair of the head is red, the beard, and the hair with which various parts of their bodies are profusely covered, are deep black, the skin being sallow, and the eyes light. This coloration is completely at variance with all known physiological relations, and it is obvious from the author's observations that the statement must have arisen from a misconception, due, perhaps, in part to the practice pursued by the Aïnos of colouring their heads a bright red, and tattooing the lips in circular rings of black and blue. The interest of racial coloration is considerable when judged from an ethnological point of view, and special importance attaches to the subject in regard to the Aïnos, who, although undoubtedly a white race, have undergone various modifications in accordance with the different parts of the empire in which they were settled. Thus, while in some districts the people have been forced to adopt the dress and habits of the Japanese, in the neighbourhood of Sapporo, the capital of the Island of Yesso, they have hitherto been enabled to retain their old customs, and keep themselves far more free than elsewhere from intermixture with the Japanese. It is, therefore, the more worthy of notice that in this district no blonde or blue-eyed Aïnos are to be met with, while the people generally have absolutely black hair. It would, in fact, appear that the hair of the normal Aïnos is of a jay-like blackness, coarse and stiff, but bright and lustrous, although in the case of a few of those who have long occupied the sea-coast, the hair is of a dark brown, presenting almost the same softness as that of Europeans. In no section of the people is there the slightest evidence of any anomalous colouring of the hair, eyes, and complexion. M. Lefèvre considers that the stature of the Aïnos is somewhat higher than that of the normal Japanese, while their cranial index, which is found to range from the extremes of dolichocephalism to that of brachycephalism, would seem to give very strong weight to the assumption that these people are not a pure race, and that they differ in accordance with the extent to which Mongolian or other ethnic elements have modified their primitive character.—On the writings and opinions of Samuel Zarza, by M. Salomon Reinach. Considerable interest was excited by a statement made in 1877 by Dr. Topinard, in one of his lectures, afterwards published in the *Gazette Médicale*, according to which a Jew, named Samuel Zarza, was burnt alive in 1450, for having maintained the antiquity of man. This statement excited much attention, and M. Cartailhac, who doubted its accuracy, appealed to his *confrères* for information in regard to the documents from which M. Topinard had quoted. This appeal remained unanswered until the question was lately taken up by M. Reinach, who associated with himself in the necessary investigations a learned Russian Jew, M. Salomon Fuchs. To the latter we are indebted for a commentary on the numerous works of Zarza, surnamed Ben S'né, which, according to his own report, were undertaken in the hope of reviving among his co-religionists in Spain their interest in philosophical and theological inquiries, which had nearly died out amid the miseries they had endured during the civil wars between Peter the Cruel and his brother, Henry II. M. Fuchs has failed to find in these works any opinion expressed concerning the antiquity of man, although the writer appears to have adhered to the belief of the eternity of the world. It is, moreover, obvious from his reference to his age when he completed his second work, entitled "Mikhalal-Yophi," *i.e.* "Perfection of Beauty," in 1369, that he could not have survived until 1450, which is given by the commentators of the seventeenth century, from whom Dr. Topinard borrowed his references, as the date of his presumed martyrdom. While M. Fuchs thus supplies another proof of the inaccuracy of many of the earlier commentators, he at the same time shows by his summary of Zarza's writings that Hebraists might throw interesting light on the early dawn of scientific inquiry by a careful study of the numerous still unprinted remains of Zarza, and of his Spanish co-religionists, who undoubtedly exercised an active influence on the progress of learning in the Middle Ages.—On the belief in familiar household spirits and other forms of superstition, by Dr. Berenger-Feraud. The interest of this paper to the student of folk-lore depends upon the writer's detailed narratives of the local superstitions still prevailing, or only recently exploded, in the rural districts of France; his elaborate exposition of the superstitions of other countries has little value for the English reader.—On questions regarding the Aryans, by M. de Lapouge. The author believes that, at the present stage of our knowledge, we are justified in assuming that in the ancient Aryans we have a blonde dolichocephalic race, whose cradle was in the north-west of Europe as it existed in the second half of the Quaternary age.—On the steatopygia of the Hottentots in the Garden of Acclimatization by M. Topinard.

SOCIETIES AND ACADEMIES.

London.

Royal Society, March 7.—"On the Wave-Length of the Principal Line in the Spectrum of the Aurora." By William Huggins, D.C.L., LL.D., F.R.S.

I think it is very desirable that I should put on record some observations of the spectrum of the aurora which I made in the year 1874, but which, up to the present time, have remained unpublished. These observations were made with a powerful spectroscope, and under conditions which enabled me to determine the wave-length of the principal line within narrow limits of error. The spectroscope was made by Sir Howard Grubb, on the automatic principle of his father, Mr. Thomas Grubb. It is furnished with two "Grubb" compound prisms; each has 5 square inches of base, and gives nearly twice the dispersion of a single prism of 60°—namely, about 9° 6′ from A to H.

The observations were made on February 4, 1874. There was a brilliant aurora, showing a whitish light; a direct-vision spectroscope resolved this light into a brilliant line in the yellow and a faint continuous spectrum.

The "Grubb" spectroscope was directed from the window of the Observatory upon the brightest part of the aurora. In the first instance, an estimation by eye was made of the position of the bright line by comparing it in the instrument with the spectrum of a spirit-lamp. The bright line was seen to fall on the more refrangible side of the line for which Watts gives the wave-length 5582 (*Phil. Mag.*, vol. xli., 1871, p. 14), Ångström and Thalén 5583 ("Spectres des Métalloïdes," *Nov. Act. Soc. Sci. Upsal.*, vol. ix., 1875, p. 29), by from one-fifth to one-fourth of the distance of this line from the beginning of the band. If we take one-fourth, we have λ 5569·6; one-fifth gives λ 5572·3. The mean of these values gives for the

Aurora line λ 5570·9 . . . . (1)

The cross-wires of the spectroscope were then brought upon the line, and the reading 3476 showed the line to fall about midway between two strong lines in the spectrum of tin, λ 5564 and λ 5587 respectively, according to my measures ("Spectra of the Chemical Elements," Phil. Trans., 1864, p. 139). The position of the cross was then compared directly with those lines in the spectrum of an induction spark taken between electrodes of tin. The further details of this comparison are not given in my note-book, but the result only, which placed the

Aurora line at λ 5571 . . . . (2)

Consulting my map of the chemical elements, I found that there was a line of tellurium very near this place—namely, at λ 5575; I therefore brought the spark from tellurium before the slit, when the cross appeared on the more refrangible side of the tellurium line. The measure of the distance of the cross from this line came out equal to λ 0003. The place given in my paper for this line of tellurium is 5575. Thalén gives for the same line 5574·1 (Brit. Assoc. Rep., 1885, p. 292). If we take the mean of these values and deduct 0003, we get for

The line of the aurora λ 5571·5 . . . . . (3)

There are strong lines of iron very near this position in the spectrum, and I made use of these also for a further determination of the place of the aurora line. The cross, after having been placed upon the line of the aurora, was confronted with these lines in the spectrum of iron.

The condensed account in my note-book does not give further particulars of this comparison, but states only that the place of the

Aurora line came out λ 5571·5 . . . . . (4)

Summing up these determinations we have—

(1) Eye-estimation	λ 5570·9
(2) From tin	5571·0
(3) From tellurium	5571·5
(4) From iron	5571·5

From these values I think that we are justified in taking for the aurora line, as a position very near the truth,

λ 5571 ± 0·5 . . . . (5)

Among the numerous determinations of other observers, those of Prof. H. C. Vogel in 1872 (*Lepzig Math. Phys. Berichte*, vol. xxii. p. 285) seem to me to have great weight. A direct-vision spectroscope with a set of five prisms was used. The reduction of the readings of the micrometer into wave-lengths was based upon the repeated measures of 100 lines of the solar spectrum.

The screw had been thoroughly examined. After each observation of the aurora line, readings were taken of the lines of sodium or of hydrogen. The observations extended over four nights. On three nights four separate readings were obtained; on the fourth night two only. Vogel gives as the mean result of the fourteen observations—

Aurora line λ 5571·3 ± 0·92 . . . . . (6)

The recent observations on the spectrum of the aurora by Gyllenskiöld, at Cap Thordsen, in 1882, deserve special mention.[1] With a Hoffmann spectroscope, furnished with a scale, he obtained at Cap Thordsen in 1882 a mean result of λ 5568 ± 1·6; later, in 1884, at Upsala, with a Wrede spectroscope furnished with a micrometer screw, a mean value for the aurora line, λ 5569 ± 6·2.[2] Gyllenskiöld discusses in detail nearly all the recorded observations of the spectrum of the aurora from 1867 to 1882, and then brings them together in a table, with such probable errors as the original statements of the observers enabled him to assign to them.

Gyllenskiöld then calculates by the method of least squares the mean value of all the determinations, and finds the following result:—[3]

Mean value of the 23 observations, λ 5570·0 ± 0·88 . . (7)

The recent measures by C. C. Krafft,[4] depart largely from Gyllenskiöld's mean value. Krafft found on

1882 November 2	λ 5595
,, ,, 11	5586

and measures with the same instrument made by Schroeter, on November 17, gave λ 5587.

Now, though Ångström's original value, λ 5567, may not be quite accurate, his observation fixed a limit towards the red beyond which the aurora line cannot lie. Angström says: "Sa lumière était presque monochromatique, et consistait d'une seule raie brillante située à gauche" (on the more refrangible side) "du groupe connu des raies du calcium" ("Spectre Solaire," Upsal, 1868, p. 42). The position of the most refrangible line of this calcium group is accurately known; according to (Brit. Assoc. Rep. 1884, p. 372)

Kirchhoff	λ 5580·9
Thalén	5580·9
Huggins	5581·0

It is certain therefore, from Ångström's first observation in 1867, alone that the aurora line lies well on the more refrangible side of wave-length 5580. This limit towards the red was confirmed afterwards by Ångström himself; he says later that the yellow line falls almost midway between the second and third line of the shaded carbon group (NATURE, vol. x. p. 211). The positions of these lines of comparison are, according to Ångström and Thalén, λ 5538 and λ 5583 (*Acta Upsal.*, vol. ix. 1875, p. 29).

It follows that Krafft's values, λ 5586, λ 5587, and λ 5595, must be from some cause inaccurate. A possible explanation may be found in the small number of solar lines employed by Krafft for the reduction of the measures into wave-lengths. The curve was drawn through the six Fraunhofer lines, B, C, *a*, D, E, and *b*. There was no control for the curve between D and E, and a very small deviation of the curve from its true position here would be sufficient to account for the position of less refrangibility of from λ 0016 to λ 0024, which his measures give for the aurora line.

It should be stated that Krafft expresses regret that more attention could not be given to the spectroscopic observations. He says:—"Leider gestatteten die obligatorischen Beobachtungen nicht, den spectroscopischen Untersuchungen die gehörige Aufmerksamkeit angedeihen zu lassen. . . . Ich glaubte ausserdem diese Messungen um so mehr auslassen zu können, als der Platz der gewöhnlichen Nordlichtlinie oft und sehr genau bestimmt ist."

To sum up, we have the following values for the principal line of the aurora:—

(6) 1872, Vogel	λ 5571·3 ± 0·92
(5) 1874, Huggins	5571·0 ± 0·5
(7) Gyllenskiöld's mean of twenty-three observers from 1867 to 1884 . . .	5570·0 ± 0·88

These values agree closely, and fix within very narrow limits, the position in the spectrum where we have to seek the chemical origin of the line.

Gyllenskiöld, from his observations of the changes which occur in the spectrum of the aurora, comes to the conclusion

[1] "Observations faites au Cap Thordsen, Spitzberg, par l'Expédition Suédoise," vol. ii. part 1, "Aurores Boréales," par Carlheim-Gyllenskiöld (Stockholm, 1886).

[2] *Ibid.* p. 166.

[3] *Ibid.* p. 169.

[4] "Beobachtungs-Ergebnisse der Norwegischen Polarstation," &c. A. S. Steen (Christiania, 1888).

that "le spectre de l'aurore boréale résulte de la superposition de plusieurs spectres différents," and that "la raie principale forme un de ces spectres élémentaires ; elle apparait très souvent seule." A similar view was taken many years ago by Ångström (NATURE, vol. x. p. 210) and by Vogel (*Leipzig Math. Phys. Berichte*, vol. xxiii. p. 298).

[After consideration, I think that I ought to point out that Mr. Lockyer's recent statement (Roy. Soc. Proc., vol. xlv., 1889, p. 234), that "the characteristic line of the aurora is the remnant of the brightest manganese fluting at 558," is clearly inadmissible, considering the evidence we have of the position of this line.

In support of this statement Mr. Lockyer says :—"Ångström gave the wave-length of the line as 5567, and since then many observers have given the same wave-length for it, but probably without making independent determinations. Piazzi Smyth, however, gives it as 558, which agrees exactly with the bright edge of the manganese fluting. R. H. Proctor also gives the line as a little less refrangible than Ångström's determination. He says: 'My own measures give me a wave-length very slightly greater than those of Winlock and Ångström' (NATURE, vol. iii. p. 468)."

By reference to Gyllenskiöld's table it will be seen that the probable errors of the determinations by Piazzi Smyth and Proctor, 5579 ± 9·5 and 5595 ± 25·0 respectively,[1] are too large to entitle these measures to special weight.

Mr. Lockyer says, further :—"Gyllenskiöld's measures with the Wrede spectroscope also give 5580 as the wave-length of the characteristic line. I feel justified, therefore, in disregarding the difference between the wave-length of the edge of the manganese fluting and the generally accepted wave-length of the aurora line."

Gyllenskiöld's single measure of 5580, on which Mr. Lockyer relies, differs widely from the values which Gyllenskiöld himself assigns to this line—namely, from observations at Cape Thordsen in 1882, λ 5568 ± 1·6, and from observations at Upsala in 1884, with the Wrede spectroscope, λ 5569 ± 6·2.

Speaking of Krafft's observations, Mr. Lockyer says (Roy. Soc. Proc., vol. xlv., 1889, p. 241) :—"The wave-lengths obtained for the aurora line were 5595, 5586, and 5587. Unlike most observations, these place the aurora line on the less refrangible side of the manganese fluting. Hence, we have an additional reason for neglecting the difference between the wave-length of the brightest edge of the manganese fluting, and the commonly accepted wave-length of the aurora line, as given by Ångström. . . . These observations are the latest which have been published, and were obviously made with a full knowledge of all previous work, so that their importance must be strongly insisted upon."

I have already pointed out that Krafft's measures were not made under circumstances which assured to them a high degree of accuracy ; and Krafft's own words, which I have quoted, disclaim expressly any special attempt on his part to redetermine the position of the principal line with a higher degree of accuracy than the observers who preceded him.—March 4.]

May 2.—"The Accurate Determination of Carbonic Acid and Moisture in Air." By J. S. Haldane, M.A., M.B., and M. S. Pembrey (Physiological Laboratory, Oxford). Communicated by Prof. J. Burdon Sanderson, F.R.S.

The authors show that, in spite of the efforts which have been made in recent years to improve the method of Pettenkofer for determining CO_2 in free air, the results obtained by different observers still seriously disagree. They also point out the serious defect in the ordinary "chemical" method of determining moisture in air, that in spite of its superior accuracy it only gives accurate results over a long period, while the proportion of moisture in the air is constantly changing.

A method is then described for determining simultaneously the CO_2 and moisture in air. The method is gravimetric. The CO_2 is estimated by the increase in weight of an apparatus of simple construction containing soda lime, through which a known volume of the air has been passed. The moisture is similarly estimated by means of an apparatus containing pumice soaked in sulphuric acid. The increased accuracy and convenience of the method depend on the facts: (1) that a very rapid current of air may be passed through the apparatus without fear of non-absorption of either CO_2 or moisture ; (2) that by the method of counterpoising with a dummy apparatus during weighing the "errors of weighing" are reduced to about a tenth of what they would otherwise be. It is shown that with these two improvements the method for moisture gives in a period of experiment of one minute a result equal in accuracy to that obtained with the ordinary method in a period of two hours.

Using their own method for CO_2 as a standard, the authors have also tested the Pettenkofer method. They find that the latter method usually gives results for free air about a fifth too high, but that the error is less in proportion with air containing larger amounts of CO_2.

As a number of sets of absorption apparatus can easily be carried about, the new method is well suited for experiments in hygiene, and especially for cases in which a series of experiments require to be made in rapid succession. Both kinds of absorption apparatus last over a large number of experiments without refilling.

Physical Society, April 13.—Prof. Reinold, President, in the chair.—Mr. Shelford Bidwell, F.R.S., showed a lecture experiment illustrating the effect of heat on the magnetic susceptibility of nickel, and an experiment showing an effect of light on magnetism. In the first experiment a piece of nickel was attached to one side of a copper pendulum bob, which was held out of the vertical by bringing the nickel in contact with a fixed magnet. On placing a spirit-lamp flame below the nickel, the bob was, after a short time, released, and oscillated until the nickel had cooled, when it was again attracted and the operation repeated itself. The second experiment had been recently shown before the Royal Society. One end of an iron bar, which had been magnetized and then demagnetized, was placed near a magnetometer needle. On directing a beam of light on the bar an immediate deflection of the needle resulted, and on cutting off the light the needle promptly returned to near its initial position. The direction of magnetization induced by the light is the same as the previous magnetization, and the bar seems to be in an unstable magnetic state. That the effect is due to light and not heat, the author thinks is rendered probable by the suddenness of the action. The President said he had tried the experiment himself and failed to get any effect, but after seeing the arrangement of apparatus used, he believed his non-success due to the comparatively great distance between his bar and needle. Mr. C. Richardson asked if the results were different for different coloured rays, and Prof. S. P. Thompson inquired whether the magnitude of the effect varied with the intensity of illumination as in selenium, and also if any change was produced by altering the direction of vibration of the incident light. Mr. G. M. Whipple wished to know whether any difference was produced by blackening the bars, and as bearing somewhat on the same subject mentioned an induction magnetometer in which an iron bar used was demagnetized by plunging in hot water. The results obtained were very irregular after the first magnetization, and this may have been due to the instability shown to exist by Mr. Bidwell's experiment. In reply, Mr. Bidwell said red light produces most effect, and blackening the bar makes the action much slower. As regards selenium, the character of the effect is similar, but he believes the causes to be different. Polarized light produces no change. In answer to Prof. Herschel, he said that any part of the bar is sensitive to light, and showed that illuminating both sides of the bar increased the effect.—Mr. G. M. Whipple read a note on the dark flash seen in some lightning photographs. After expressing his dissent from the explanations offered in the report of the Lightning Flash Committee of the Meteorological Society and Prof. Stokes respecting ribbon lightning and dark flashes, the author described some experiments he had made on the subject. Ribbon lightning he conceived to be an effect produced by taking the photographs through windows, and to test this, lines on a blackboard were photographed, (1) direct ; (2) through good plate-glass placed obliquely ; and (3) through window-glass, the result being that the double, triple, and ribbon flashes were closely imitated. As regards "dark flashes," the author believes the appearance due to the prints being taken in oblique light, and to be produced by successive reflection from the reduced silver forming the dark line on the negative and the upper surface of the glass of the negative. Prof. Perry suggested that this might be easily proved by examining a negative, the prints from which show the dark flash. Mr. Baily pointed out that, if the explanation given were correct, the dark line should be parallel to the bright one, and this he understood was not always the case. Mr. Boys remarked that one dark flash exhibited minute wriggles not seen in the bright one, and Mr. C. V. Burton thought these might be due

[1] Gyllenskiöld's statement of Proctor's value is based on NATURE, vol. iii. p. 347 and p. 68.

to irregularities in the upper surface of the negative. Dr. Gladstone said he was not satisfied with Prof. Stokes's nitrous oxide explanation, but thought the phenomenon may be due to some kind of reversion. He also mentioned that a negative might probably be obtained from Mr. Shephard, of Westbourne Grove. As regards multiple flashes, Mr. Boys said he had often seen seven or eight flashes traverse the same path in rapid succession. On the motion of the President, the discussion was adjourned until the next meeting, when Mr. Whipple hopes to exhibit the negative referred to, together with photographs of his experimental dark flashes.—On quartz as an insulator, by Mr. C. V. Boys, F.R.S. In making quartz fibres the author observed that the ends of fibres broken during the shooting process coiled up into screws, and projected themselves against anything brought in their vicinity. After a short time they released themselves and sprang back to their original position. This could be repeated indefinitely, and the only explanation he could think of was that the fibre was electrified. If so, then to exhibit such phenomena the insulating qualities of quartz must be very great, and experiments were shown to demonstrate this deduction. A small pair of charged gold leaves were suspended from a short quartz rod in a moistened atmosphere, and the deflection fell one-quarter the original amount in about five hours. A clean glass rod under the same conditions would discharge the leaves in a few seconds. Dipping the quartz into water did not seem to diminish its insulating properties, and ordinary chemicals produced no permanent prejudicial effect. The author considers that quartz will be very useful in electrostatic apparatus, for the troublesome sulphuric acid may be dispensed with.—On a refraction goniometer, by Mr. A. P. Trotter. The goniometer, which was designed when determining the figure of a refracting surface to effect a special distribution of light, is practically a movable four-bar linkwork, representing the figure given in Deschanel (p. 924); two of the bars are parallel to the incident and emergent rays, and the other two normals to the faces of the prism. By its means the angle of a prism to produce a given deviation, when the index of refraction and angle of incidence are known, can be readily found. A series of curves expressing the relation between incidence and deviation for prisms of various angles were shown, and the same curves show the minimum deviation and limiting angle for prisms of all angles represented. The author thinks the instrument will be useful in physical laboratories for adjusting optical apparatus and for the calculation of lighthouse and other polarized lenses, Fresnel prisms, &c. Prof. Herschel said he found a wooden model illustrating the relations between the angles of incidence and refraction very useful in teaching; and Mr. Blakesley sketched an arrangement of links and cords devised for the same purpose. Mr. Boys considered that all such relations were best seen on a slide rule.—A note on apparatus to illustrate crystal forms, by Prof. R. J. Anderson, was read by Prof. Perry. The apparatus is constructed of cords, pulleys, and weights arranged to produce the required figure when in equilibrium. By increasing or decreasing some of the weights the corresponding axes of the crystal forms can be lengthened or shortened, and the passage from one system to another effected. In one arrangement the forces may be divided or united, and the pulleys are carried by rings capable of rotating on different axes. By this apparatus the various conditions are said to be beautifully illustrated, and methods of deriving the oblique from the rectangular systems are shown in photographs which accompany the paper.

Entomological Society, May 1.—Mr. Frederick Du Cane-Godman, F.R.S., Vice-President, in the chair.—Mr. W. L. Distant announced the death of Dr. Signoret, of Paris, one of the Honorary Fellows of the Society.—Dr. Sharp exhibited male and female specimens of *Rhomborhina japonica*, in which the thorax was abnormal; also, a specimen of *Batocera roylei*, which he had kept in a relaxed condition in order to be able to demonstrate the power of stridulation possessed by this species.—Dr. N. Manders exhibited a small collection of Coleoptera, including several remarkable and very interesting species, recently made by him in the Shand States, Burmah.—Mr. C. O. Waterhouse exhibited, for Mr. Frohawk, a series of wings of British butterflies, prepared in accordance with a process (described by Mr. Waterhouse in the Proc. Ent. Soc., 1887, p. xxiii.), by which they were denuded of their scales so as to expose the neuration.—Dr. P. B. Mason exhibited cocoons of a species of spider—*Theridion pallens*, Black.,—from Cannock Chase, distinguished by the presence of large blunt processes on their surface.—Mr. H. Goss exhibited, for Mr. N. F. Dobrée, a number of scales of *Coccidæ*, picked off trees of *Acacia melanoxylon* and *Grevillea robusta*, growing in the Market Square, Natal. These scales had been referred to Mr. J. W. Douglas, who expressed an opinion that they belonged to the family *Brachyscelidæ*, and probably to the genus *Brachyscelis*, Schrader. He said that most of the species lived on *Eucalyptus*.—Captain H. J. Elwes exhibited a long and varied series of specimens of *Terias hecabe*. He remarked that all the specimens which had strongly defined markings were taken in the cold and dry season, and that those which were without, or almost without, markings, were taken in the hot and wet season; further, that he believed that many specimens which had been described as distinct were merely seasonal forms of this variable species. Mr. W. L. Distant, Mr. F. D. Godman, F.R.S., Prof. Meldola, F.R.S., Mr. H. T. Stainton, F.R.S., and Mr. G. Lewis took part in the discussion which ensued.—Mr. H. Burns exhibited, and made remarks on, a number of nests of living ants of the following species, viz. *Formica fusca*, *Lasius alienus*, *L. flavus* *L. niger*, *Myrmica ruginodis*, *M. scabrinodis*, &c. One of the nests contained a queen of *L. flavus*, which had been in the exhibitor's possession since September 1882.—Mr. W. Dannatt exhibited specimens of *Thaumantis howqua*, West., from Shanghai.—Mr. G. C. Bignell communicated a paper entitled "Description of a New Species of British *Ichneumonidæ*."—Mr. A. G. Butler communicated a paper entitled "A Few Words in reply to Mr. Elwes's statements respecting the incorporation of the Zeller Collection with the General Collection of Lepidoptera in the Natural History Museum." Captain Elwes, Mr. Stainton, Mr. Godman, and others, took part in the discussion which ensued.

PARIS.

Academy of Sciences, May 7.—M. Des Cloizeaux, President, in the chair.—On elliptical polarization by vitreous and metallic reflection; extension of the methods of observation to the ultra-violet radiations, by M. A. Cornu. The principles on which Cauchy has established the theory of these two orders of phenomena and the form of the laws controlling them differ so greatly that most physicists regard them as essentially distinct. But these experiments show that this is not the case, and that the same substance may present a continuous transition from one to the other according to the nature of the reflected radiation. It follows that the phenomena presented by transparent substances with metallic sheen (fuchsine, platinocyanides, &c.), far from being exceptional, merely constitute particular forms of the general phenomenon of reflection.—On the origin of bronze, by M. Berthelot. The author has analyzed specimens from a statuette from Tello in Mesopotamia, and from the sceptre of the Egyptian king Pepi I. (sixth dynasty), both dating back to about 4000 B.C., and both consisting of pure copper. From this he argues that, as in the New World, the Stone Age was followed by a Copper Age in the eastern hemisphere, and that the bronze period cannot be more than some fifty or sixty centuries old.—On the thionic series; action of the alkalies, by M. Berthelot. Having already determined the heats of formation of the thionic compounds (*Comptes rendus*, cviii. p. 773), the author here deals with the reciprocal transformations of these compounds under the influence of the alkalies. The pentathionates, tetrathionates, and trithionates are treated in detail, and it is concluded that these as well as other compound substances, such as metaphosphoric and pyrophosphoric acids, hitherto regarded as isolated and exceptional, all come within the same general theories as the organic acids.—Note on an iron meteorite discovered buried in the ground at Haniet-el-Beguel in Algeria, by M. Daubrée. This meteorite, found at a depth of 5 metres, while sinking a well in the Wed Mzab district, appears to be of great age, having fallen probably during the Quaternary epoch. It shows the Widmanstätten figures quite distinctly, and its other characteristics place its extra-terrestrial origin beyond all doubt.—Remarks accompanying the presentation of the third part of the *Bulletin international de la Carte du Ciel*, by M. Mouchez. In these remarks special attention is called to Mr. Isaac Roberts's *pantograveur stellaire*, an ingenious and valuable process, by means of which the photographic impressions of the stars can easily be transferred to metallic plates, and thus preserved from all danger of perishing. The method is simple and economical, and allows of an unlimited number of copies being taken for general use. By this invention all risk is removed of the labours of the International Association for photographing the Heavens being lost to future generations.—Researches on the application of the measurement of rotatory power to the study of the compounds formed by the action of the magnesium and lithium molybdates on the solutions of tartaric acid, by M. D. Gernez. The present series of experiments are analogous to those already described in previous communications, demonstrating the great increase experienced by the rotatory force of certain active compounds when their solutions are placed in contact with various substances without proper action on polarized light. Here M. Gernez studies more particularly the action of the neutral magnesium molybdate on solutions of tartaric acid, and the action of the neutral lithium molybdate on the same solutions. Combining these with the results already obtained, he is now able to formulate the following general conclusion: The simplest combinations which are produced in aqueous solution between tartaric acid and the neutral molybdates and tungstates hitherto studied, and which correspond to a maximum rotatory power, are formed by the union of the acid with the salt molecule for molecule.—On the atomic weight of ruthenium, by M. A. Joly. In a previous communication (*Comptes rendus*, cvii. p. 994) the author announced that the analysis of compounds of nitric oxide with rutheno-chlorides led to a reduction of about two units in the atomic weight of ruthenium (104–103·5) as determined by the latest researches of Claus. He now finds this view confirmed by his own studies, and provisionally fixes the atomic weight of this element at 101·4. In its preliminary transformation into compounds containing nitric oxide the ruthenium was completely freed from osmium, the atomic weight of which, according to Seubert's last determinations, is nearly double (191), and this would explain the considerable reduction in the atomic weight of the ruthenium itself.—On α-oxycinchonine, by MM. E. Jungfleisch and E. Léger. A detailed description is given of the preparation, properties, salts, and various derivatives of this substance, the formula of which is $C_{38}H_{22}N_2O_4$.—On the alcoholic fermentation of the juice of the sugar-cane, by M. V. Marcano. The object of these studies has been to determine the agent of the alcoholic fermentation, as well as the nature of the products accompanying the alcohol yielded by the juice of the sugar-cane.—Action of zinc chloride on isobutylic alcohol in the presence of hydrochloric acid, by MM. H. Malbot and L. Gentil. The points here chiefly studied are the part played by the isobutyl chloride, and the properties of the polybutylenes.—On an artificial silk, by M. de Chardonnet. The author has prepared from a pure cellulose octonitrate a silk-like fabric of great elasticity and softness, more lustrous than the silk of cocoons, and capable of being dyed by the ordinary processes. Specimens will be shown at the Universal Exhibition.—M. Daubrée paid a tribute to the memory of the late M. Lory, Corresponding Member of the Section for Mineralogy, who died at Grenoble on May 3.

BERLIN.

Physical Society, April 5.—Prof. von Helmholtz, President, in the chair.—Prof. Rosenthal, of Erlangen, described his calorimeter and the experiments he had made with it on the heat-production of the animal body. (See report of the Physiological Society in NATURE of April 25, p. 624.) He then showed a small experiment on making flames non-luminous. This result can be obtained either by means of a strong current of air or by considerable cooling. The speaker, however, produced the same effect in the following way. A small gas-flame is made to burn brightly inside a cylindrical chimney; it becomes non-luminous as soon as a platinum crucible is placed on the chimney so as to incompletely close the upper end of the cylinder. Prof. Rosenthal believes that in this case the current of air through the chimney is very considerably slowed, hence the gas issuing from the burner becomes disseminated throughout the whole mass of air, and as a result of this, the temperature being low, it burns without giving any light. Several other explanations of the phenomenon were suggested by the members present at the meeting.—Dr. Fröhlich made a further communication in connection with his older, resultless experiments on the objective demonstration of the vibrations of a telephone-disk, in order to describe his new method by which positive results had been obtained. In his earlier experiments he employed manometric flames, and endeavoured to photograph their movements with the help of a rotating mirror; now, however, he attaches a small mirror to the iron plate of the telephone, and from this the light of an electric lamp is reflected on to a polygonal rotating mirror, from which it falls upon a screen. The vibrations of the plate were thus made visible on the screen, and since each side of the polygonal mirror cast its own image, when the mirror was rotated the curves were seen moving over the screen. The more rapidly the mirror was rotated the slower did the curves move over the screen, and when the rotation was as rapid as the vibration of the plate, the curves became stationary and could thus be exactly observed and drawn. These luminous curves could also be photographed. The speaker had employed this method in a series of researches on certain electrical phenomena which might influence the efficiency of the telephone. Thus the action of alternating currents, of self-induction, of the rise and fall of the current on making and breaking, of the introduction of electro-magnets, and of other conditions, were studied by means of the altered mode of vibration of the telephone plate. The speaker had further obtained a graphic record of the vibrations of the telephone plate when vowels and consonants are sung and spoken into it. Many other problems may, by the above method, be brought nearer to their solution.—Dr. Reichel showed a lecture-experiment with a water-hammer. When the bulb in which the fluid is contained is grasped in the warm hand, the fluid is driven over to the other side by means of the vapour which is then formed. When all the fluid has thus passed over, bubbles of vapour finally make their way through the fluid, and at this moment the hand which is grasping the bulb experiences a distinct sensation of cold.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Illustrations of Zoology: W. R. Smith and J. S. Norwell (Pentland).—South Africa as a Health Resort, 2nd edition: A. Fuller (Whittingham).—A Dictionary of Explosives: Major J. P. Cundill (Mackey, Chatham).—Three Cruises of the *Blake*, 2 vols.; Bulletin of the Museum of Comparative Zoology at Harvard College, in Cambridge, vols. xiv. and xv.: A. Agassiz (Cambridge, Mass.).—Bibliography of Meteorology—Part 1, Temperature: edited by O. L. Fassig (Washington).—Mr. Stranger's Sealed Packet: H. MacColl (Chatto and Windus).—Travels in the Atlas and Southern Morocco: J. Thomson (Philip).—A Treatise on Trigonometry: W. E. Johnson (Macmillan).—Darwinism: A. R. Wallace (Macmillan).—Life of Charles Blacker Vignoles: O. J. Vignoles (Longmans).—Gleanings from Japan: W. G. Dickson (Blackwood).—Celestial Motions, 6th edition: W. T. Lynn (Stanford).—Our Fancy Pigeons, cheap edition: G. Ure (Stock).—Natural Science Examination Papers—Part 1, Inorganic Chemistry: R. E. Steel (Bell).

CONTENTS.

THURSDAY, MAY 23, 1889.

THE NEW TECHNICAL EDUCATION BILL.

AFTER the storms which have wrecked so many previous attempts to deal with the question of technical education, it is no less surprising than gratifying to find that on Wednesday, May 8, Sir Henry Roscoe's Bill, representing the views of the National Association for the Promotion of Technical Education, slipped through the second reading stage in less than a minute, with no opposition and amid general cheers. If would be too much to expect that the same easy course lies before the Bill in Committee, but at least it may be said that we are much nearer the settlement of this vexed question than we seemed to be a month ago.

The Bill itself, which we reprint elsewhere, does not differ materially from its predecessor of last year —we mean the Bill introduced last year by Sir Henry Roscoe, not the hapless measure drafted by the Government. There is, indeed, an alteration in the definition of technical education, which now includes, besides instruction in the branches of science and art named in the Science and Art Directory, the working of wood, clay, metal, &c., commercial subjects, and "any other subject applicable to the purposes of agriculture, trade, or commercial life and practice, which may be sanctioned by a minute of the Department of Science and Art made on the representation of a School Board or local authority that such a form of instruction is suited to the needs of its district." This is an improvement on last year's definition, which gave the initiative in this matter to the central Department instead of the local authorities. The more freedom that is given to localities to adapt their scheme of technical instruction to the diverse needs of their own industries the better.

But the Bill is essentially unaltered, and it ought to meet with the same approbation from friends of education as greeted its predecessor. It is, like all the measures that have been drafted, an enabling Bill; that is to say, it gives powers to localities to provide technical instruction if they think fit. The Bill deals with the case both of elementary and secondary schools. Technical instruction given in the former will be provided by the School Board, and a school will not cease to be a public elementary school by reason of technical instruction given therein. If, however, a School Board fails to do its duty in the matter, the local authority (*i.e.* the County, District, or Borough Council, or the Urban Sanitary Authority, as the case may be) may step in and make the requisite provision themselves. In the case of higher technical instruction, provision may be made either by the School Board or, except in the case of London, by the local authority. Provision is made for the payment of fees of deserving students, the establishment of scholarships, grants for laboratories, apparatus, museums, libraries, &c. Grants may be made to the higher technical schools by the Science and Art Department, and to elementary schools giving technical instruction by the Science and Art Department, or the Education Department, or both.

The Bill was allowed to pass the second reading unchallenged only on the understanding that certain alterations should be made in Committee. Until the Government amendments are put on paper, it is hard to give an opinion as to the future chances of the measure. It would of course be out of the question to try to revive the clause of the last Government Bill compelling School Boards either to abstain from providing technical instruction altogether, or to make the same provision for voluntary schools as for schools under their own management. It ought not, however, to be difficult to arrange a satisfactory compromise, and so remove what is undoubtedly a defect in the present measure as it stands, viz. the absence of any provision for the large majority of children who are educated in denominational schools.

It would, indeed, be pitiable if the settlement of the question were again postponed owing to the endless difficulty of the relation between Board and voluntary schools. After all, it should be remembered that by far the most important part of technical instruction necessarily falls within the realm of secondary, not of elementary education. The ground may be prepared in the primary school, but that is nearly all. In our opinion, therefore, the most important clauses of the Bill are those dealing with non-elementary schools, and at all costs these must be preserved, and, if possible, extended; for, as we read the Bill, it is doubtful whether they give the local authority the requisite powers to build new technical schools. This, however, is a matter which can easily be set straight in Committee.

We do not wish to undervalue the part of the Bill dealing with elementary schools. It is most undesirable that a School Board that wishes to build a workshop, or provide tools for manual training, should continue to run the risk of surcharge by the auditors, and it is right that the work of the so-called higher elementary schools should be formally recognized, and established on a satisfactory basis. But if there are any who expect, as a result of the measure, that a system of distinctively technical instruction will be introduced wholesale into our elementary schools, they are destined, in our opinion, to be disappointed.

We note with pleasure that the present Bill is not hedged round by the cumbrous and harassing restrictions which disfigured the Government Bill of last year. There is no requirement of a poll, no restriction in the amount of the rate; and, above all, no clause restricting technical instruction in elementary schools to children in the sixth and seventh standards. Of all alterations that may be proposed, an amendment embodying the last-named restriction would, in our opinion, be the most disastrous. It would at once cripple the work of the higher elementary school, and destroy science as a class subject and (in the fifth standard) as a specific subject throughout our elementary school system. The representatives of the Technical Education Association will doubtless be on the watch to see that no sinister alteration of this kind is introduced, for it would virtually convert the Bill into a measure for prohibiting the provision of technical instruction throughout the greater part of the elementary school course.

There are one or two criticisms which we may offer on the measure as it stands. In the first place, it does nothing for girls—for instruction bearing on domestic economy can hardly be brought under any of the heads enumerated in Clause 11. This objection might be met by slightly extending that clause so as to include cookery, laundry work, &c. Another flaw is the omission to provide expressly for Imperial grants other than payments on results of individual examination. It is true that the Bill leaves the mode in which such grants shall be made to the discretion of the Science and Art Department, but something more definite than this is required. It would be a great mistake if payments for technical instruction were made on results, like the present Science and Art grants; they ought rather to bear a certain proportion to local contributions, and a clause to this effect should, if possible, be embodied in the Bill. Lastly, why should School Boards and local authorities be required to confine any entrance examination which they may institute, to reading, writing, and arithmetic?

In spite of these minor defects in matters of detail, the Bill as a whole ought to meet with the hearty approval of the public, and we trust no stone wi l be left unturned to secure that it shall be passed into law this session. Another year's delay would be most disastrous, as it would have the effect of paralyzing local activity, especially in those centres which have already prepared schemes and collected funds for technical schools, but are waiting year after year to see what form legislation on this subject will take.

A TEXT-BOOK OF HUMAN PHYSIOLOGY.

A Text-book of Human Physiology. By Dr. Austin Flint. Fourth Edition. (London: Lewis, 1888.)

THE present edition of Dr. Flint's "Human Physiology" is a capital manual of the subject. The book has been re-written from the third edition, which was published nine years ago. As might have been expected from the author of the previous work, the style of the text is always clear and eminently readable. Upon the whole the selection of the matter is good, and the illustrations are almost without exception excellent. Detailed description of apparatus and of methods of experiment has been excluded as unsuited to the character of the book. In the same way digression into the laws of physical and chemical science has been avoided as far as possible, on the ground that such knowledge is already within the possession of the student of physiology, or that to obtain it he can turn with advantage to special treatises.

Amid much that is praiseworthy in the work, one may single out some points for especial commendation. The brief historical introductions to certain chapters are of marked excellence, and notably the sketch relating the progress in our knowledge concerning the functions of the heart and blood-vessels. The discussions of the terms hunger and thirst, and of the value of the various constituents of the urine as indices of the general metabolism of the body, are exceedingly full and satisfactory. Very interestingly given, too, is the account of the uses of water and inorganic chemical substances which pass through the organism; and the probability of the formation of a considerable amount of water within the organism during severe muscular exercise is related with striking vigour and force of argument. As its title implies, the volume is devoted particularly to the physiology of man, and the portion dealing with the special mechanisms for voice and speech is exhaustive. The chapters upon the cranial nerves, upon sight, and upon hearing, are perhaps, upon the whole, the best in the entire volume. The illustrations to these chapters are particularly deserving of praise.

In a science developing with such rapidity as of late years physiology has done, peculiar difficulties stand in the way of furnishing a text-book that shall pretend to some degree of completeness, and shall at the same time avoid statement of all that is not absolutely worthy of credence. Dr. Flint has to a great degree succeeded in accomplishing this difficult task. But he has done so somewhat at the expense of matter that might, we think, have been introduced into his text-book with advantage. One finds no definite mention in his work of rhythmic contractility as a function of the fibres of the cardiac muscle *per se*, apart from nervous connections they possess. There is no adequate discussion in this manual, consisting of nearly 900 pages, of the phenomenon of inhibition as an exhibition of temporary diversion of cell-activity into channels of anabolism. When treating of uric acid the writer is silent as to the synthesis from urea and glycocoll, although that fact throws a flood of light upon the origin of the acid in the animal body. A long paragraph is devoted to the pineal gland, and finally the remark is made that in structure it resembles the ductless glands; surely such a suggestion is worse than worthless, in view of the discovery of its relation to the dorsal median eye of Sphenodon.

On the other hand, when writing of the superficial and deep reflexes, no hint is given of any doubt as to the truly reflex nature of the latter. The balance of evidence is decidedly in favour of the patellar jerk being really of the nature of a reflex, yet an unqualified statement on so important a subject is scarcely fair to the student.

In so excellent a chapter as that on sight, it is disappointing to find hardly one word of mention of the phenomena of colour-sensations. The Young-Helmholtz theory is not alluded to, much less any rival hypothesis such as that of Hering. One hears nothing of three primary sensations of colour, or that colour-blindness is most frequently a defect for the rays of the longer wave-lengths. In a physiological work treating especially of man, this ought not to be the case. We are not so poverty-stricken in our knowledge of the functions of the semicircular canals as Dr. Flint would let his reader imagine. No adequate description is given of the symptoms which appear when they are separately injured. No adequate representation is made of the views of the long series of more recent workers on the subject. In the statement of the motor-paths by which nervous impulses arrive at the urinary bladder, no reference is made to the sacral spinal nerves, although the contraction brought about through sympathetic channels is incomparably weaker than that effected along the former route. One must add here, however, that the diagram, from Küss, exhibiting the various forms and positions assumed by the organ in question when distended in various degree, is remarkably useful and well-chosen.

Dr. Flint alludes to, rather than describes, the way in which, by partial superposition and fusion of simple contractions, the tetanic contraction of muscle is obtained. He is far too brief upon the matter, especially as he gives it no pictorial illustration in aid of his text. The student whose grains of knowledge on this head had been gleaned only in the five-lines field that Dr. Flint here allows him, would, one must think, find his garner too empty to satisfy the pillaging of the College examiner. And one sincerely hopes he would. On the other hand, upon the very next page, the significance of the so-called vibration of voluntary muscular contraction is treated in a thoroughly satisfactory way, and in view of extremely recent experiments

One might have expected, in a text-book of human physiology, to find some description of experiments in hypnotism, or at least some mention of the matter. It is a subject that more and more demands attention from the physiologist and from the physician, and a subject to which the student of medicine can have no better introduction than from the objective, non-metaphysical side from which the physiologist makes his inquiries. One has failed to discover any reference to the subject in this work.

A few instances of curious, and one may say unjust, omission of certain authorities demand mention in a notice of the book. On p. 53 it is related that following ligature of the coronary arteries the heart ceased to beat after a mean interval of twenty-three and a half minutes in six experiments by Erichsen. One would have thought the laborious and all-important research on this subject by Cohnheim and his pupil, Von Schulthen-Rechberg, not to speak of previous work by Panum, and by Samuelson, and Von Bezold, was at least worthy of some comment in the connection, and the more so that the results obtained were so infinitely more significant and valuable than those of the experiments here quoted by Dr. Flint. In describing the endings of nerve-fibres in the fibres of striated muscle, Doyère and Rouget are mentioned, and very properly so; but the name of Kühne does not appear, and nothing is said of the nucleated "sole." The description, too, is illustrated by two figures from Rouget, more than a quarter of a century old. On p. 262 occurs the following:—"It is possible, however, that future researches may show that micro-organisms play an important part in actual digestion, as is foreshadowed in a recent article by Pasteur (August 1887). Pasteur has isolated seventeen different micro-organisms of the mouth. Some of these dissolved albumen, gluten, and caseine, and some transformed starch into glucose." "These observations are very suggestive, and they seem to open a new field of inquiry as regards certain of the processes of digestion." To most readers, these lines would certainly infer that observations of this kind had first been recognized in their full bearing by Pasteur, or that, indeed, the observations of Pasteur were the earliest or the most important of the kind. To do this is to do signal injustice to a large number of investigators, who, possessed of the idea, have obtained experimental evidence of its truth, much more complete than, and several years in advance of, that published by Pasteur. One need only mention the names of Duclaux, Marcano, Hueppe, Miller, Wortmann, Escherich, Bourquelot, Brieger, Wolff; and there are many others.

A minor point on which one is inclined to join issue with Dr. Flint is the terminology he employs. He does not employ the word metabolism, but the notion is expressed by employment of "assimilation," and "dis-assimilation." The latter has a peculiarly uncouth ring. The words "anabolism" and "katabolism" one does not find. To speak of serum albumin as serine; of paraglobulin as metalbumen, and of this last as "dissolved fibrin" is likely to render more confused subjects that are sufficiently so already. It is not usual to spell the name lecithin indiscriminately lecithene and lecethine. Gustation and olfaction are not pretty words.

In the matter of illustrations the volume is thoroughly and artistically equipped. Fig. 64 and one or two more of the same kind are, however, severe blemishes. How, one asks, can the drawing of a dog with a fistulous wound in the body benefit the student? What good purpose can it subserve? The figure is a useless, gratuitous exhibition of what must to every mind be the unfortunate and repulsive accompaniment of physiological research. Intellectual and material boons conferred upon society justify to the full a pursuit of the science in despite of every difficulty of this kind, because those boons can be obtained for it by no other course of action. They do not, however, justify for such a book as Dr. Flint's one single picture such as those referred to.

As was to be expected, the question of the elimination of nitrogen from the body is treated with that pleasant decision and competence that can be assumed only by an author who has himself carried on research in the field of which he is writing. The observations of Dr. Flint upon Weston the pedestrian are seemingly at variance, as he remarks, with those of Parkes, and of Fick and Wislicenus, made upon other persons. The suggestion is valuable that the difference may be explained by the much more strenuous character of the exertion undergone by Weston than by Parkes's soldiers, or by the physiologists who walked up the Faulhorn. Dr. Flint found that the excretion of urea was increased by a walk of 100 kilometres a day for five consecutive days, the walker being upon the same generous diet during as well as before and after the exertion. Fick and Wislicenus during their ascent and for a short time beforehand abstained from all nitrogenous food. They found an actual decrease in the amount of urea excreted in the period of exertion. But in the main result the researches are in accord. They all alike fail to yield evidence of increased degradation of proteids sufficient to account for the increased quantity of energy set free.

In conclusion one has to add one word in praise of the form and typography of the book. It is evident that, as the author says in his preface, "the publishers have spared nothing in the mechanical execution of the work." C. S. S.

GEOGRAPHY IN GERMANY.

Beiträge zur Geophysik: Abhandlungen aus dem geographischen Seminar der Universität Strassburg. Herausgegeben von Prof. Dr. Georg Gerland. I. Band. (Stuttgart: Koch, 1887.)

Bericht über die Entwickelung der Methodik und des Studiums der Erdkunde. Von Prof. Dr. Hermann Wagner. Im *Geographisches Jahrbuch*, 1888. (Gotha: Perthes.)

IN 1886–87 there was much discussion among English geographers about the limits and methods of their subject. The whole matter had been gone into by the Germans a few years before. It is curious to note that just when we had relapsed into something like silence on the point, and had agreed to put our views to the test of practice, the debate was vigorously revived in the Fatherland. In part this was the effect of the sympathy and of the supply of material for criticism which came across the water, but in the main it was due to Dr. Gerland's striking introduction to the first volume of the Strassburg "Contributions to Geophysics." In the last *Geographisches Jahrbuch* Dr. Wagner sums up both the English and the German discussions, and, though he differs radically from Dr. Gerland's fundamental positions, he gives to his essay the place of honour. The clearness and richness of its style, the closeness of its argument, the extreme and unhesitating views it enunciates, and its author's great experience command attention, and must be the excuse for once more bringing an almost threadbare subject before English readers.

The three propositions which Dr. Gerland aims chiefly at establishing are that geography has to deal not merely with the earth's surface, or even the earth's crust, but with the earth as a whole; that the human element should be shut out entirely from the view of the geographer, and that geography must be a single science characterized by a single method of investigation, the "mathematical-physical" to the exclusion of the "biological-historical." He defines the task of geography as the study of the "interaction between the earth's interior and the earth's surface," of the "interaction of the forces connected with the earth's matter, and the arranging and rearranging—the development—of the earth's matter as a result of these forces;" in a word of "the earth as a whole," the surface being but the expression of the interior. He enumerates five "geographical disciplines"—mathematical geography, geophysics, *Länderkunde*, geography of organisms, history of geography—and of these geophysics is the most important. He regards mathematics, physics, and geology, as the sciences auxiliary to geography, but mathematics as the least dispensable. He agrees with the views expressed in England in 1887, in laying down the difference between geology and geography as consisting not in the objects studied, which are to a certain extent the same, but in the point of view from which they are studied. After comparing the definitions and programmes of geology according to Naumann, Lapparent, Lyell, and Credner, he terms geography the science of the forces of the earth as a whole (*Kräfte der Gesammterde*); geology, that of the structure of the earth's crust (*Structur der Erdrinde*). It should be noted that his *Länderkunde* is purely physical, the "special part of geophysics"; and that his geography of organisms refuses to touch the organism man. He excludes the human element, or, to use Ratzel's term, *Anthropogeographie*, from geography, on the grounds that, while geography is a science auxiliary to history, the converse is not true; that geography would have two methods—the "mathematical-physical-exact" and the "biological-historical-conclusive"; that mastery of the two methods exceeds the power of one man, and that, as an educational discipline, geography loses force and logical cohesion owing to the mixture of the two methods. He assigns anthropogeography to the historian, whose point of view is that of the microcosm, man.

Dr. Gerland claims for geography, as defined by him, that it is a single science, dealing with a homogeneous mass of facts, with one method and a logical unity, making it a true field for the investigator, and of value to the teacher. His essay of fifty-four pages contains a wealth of examples and of neat formulæ which compel admiration; but it is questionable whether he does much good with his chief positions. With Dr. Wagner, we are disposed to think that he exaggerates the importance of his point that the earth *as a whole* is the subject of geography. He keenly combats the view that the surface of the earth, the topographical, is the specific characteristic of geography. Yet surely the burden of what has been recently said, on the part even of those who hold this view, has been that you must not stop short at the defining of relative position, but inquire into causes, and those causes lie largely within the earth. But Dr. Gerland's second position, his uncompromising exclusion of the human element, has more substance. Bold though he is, he has not dared to exclude the geography of (non-human) organisms. Does not his inconsistency here invalidate his programme? All through his essay one fancies there is a certain undertone of contempt for the merely probable results of anthropogeography. But are the results of the investigation of the distribution of animals at best more than highly probable? Are they not attained by the biological-historical-conclusive method? Are they capable of mathematical expression or certainty? Again, is it fatal to geography that it is too much for one man? Is any man equally master of all the methods of any science? Dr. Gerland is hardly fair to anthropogeography. He says, "river and town are heterogeneous conceptions which geography can never bind logically together." Surely a river may be viewed under two aspects—physical and human. It is part of a great circulation beginning and ending in the ocean, and it is an obstacle or an advantage, according to circumstances, to human communication. Lines of human communication and points of human settlement are not heterogeneous conceptions.

But the real seriousness of Dr. Gerland's contention lies in its results in education; indeed here only is it important. You cannot hedge in the original investigator; you cannot forbid him to cultivate the march-lands which sever the different fields of knowledge. You are only entitled to define what you expect of a geographical teacher and text-book. To exclude the human element would be fatal to the early or general learning of geography. None but mathematical specialists have the preliminary knowledge needed for Dr. Gerland's geography. It would be equally bad to have two geographies, one for the schoolmaster, another for the professor, for it is just because the Universities have neglected this subject that the school teaching has been so ineffectual. Logically, mathematical geography should no doubt come first, but a teacher rarely does well to begin his teaching with the first principles of his subject. H. J. MACKINDER.

OUR BOOK SHELF.

Gleanings from Japan. By W. G. Dickson. (Edinburgh and London: W. Blackwood and Sons, 1889.)

AFTER an interval of twenty years, Mr. Dickson revisited Japan in 1883-84, and in the present volume he gives an account of what he saw. The book contains no very novel information; so many travellers have lately recorded their impressions of Japan that it would now be hard for a writer to present any part of the subject from a wholly new point of view. Nevertheless, Mr. Dickson's book is one of exceptional interest, for, having already been in Japan, and having carefully studied its history, he knew exactly, on his return, the kind of phenomena which it would be best for him to study. Accordingly, we find in his narrative that he fastens attention chiefly on what is really characteristic of Japanese life, and that he understands how to connect particular facts with the general tendencies of Japanese society. Mr. Dickson was, of course, greatly struck by the enormous changes which had taken place from the time when he had formerly visited Japan, and he adds largely to the value of his observations by steadily comparing and contrasting the conditions which came under his notice four or five years ago with those he had noted twenty years before. About Japanese customs and institutions, so far as they are of native origin, he writes in a kindly and appreciative spirit; and he also finds something to admire in the effort of the educated classes "to advance in Western learning and the acquisition of scientific information." He declines, however, to commit himself to any very decided opinion as to the future of Japan. That she may have serious troubles in store for her he does not dispute; but, if they come, they will, he thinks, spring altogether from internal causes, and he has sufficient respect for her rulers to suggest that they "may have wisdom to avert a crash."

Statics for Beginners. By John Greaves, M.A. (London: Macmillan and Co., 1889.)

To simplify the subject of statics, and to make it attractive at the same time, is by no means an easy task, but the author of this little book has gone far towards succeeding in doing this. With the approval of several experienced teachers, the principle of the transmissibility of force has been discarded in favour of the ordinary method. The parallelogram of forces is deduced from the laws of motion, Duchayla's proof being given as an alternative. The definitions are admirable, and the various proofs are as simple as they well can be.

The examples are progressive and very numerous, typical ones being fully worked out.

The book is admirably adapted to serve as a stepping-stone to the larger treatises.

LETTERS TO THE EDITOR.

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The Structure and Distribution of Coral Reefs.

As I have had no personal experience of coral-reefs, I do not wish to touch more than the literary side of the controversy, but, in regard to this, Mr. Guppy's letter in the last number of NATURE (p. 53) obliges me to call attention to the fact that the "90-fathom reef" which he mentions is not at Socotra, but at Rodriguez. Also that, apart from Mr. Guppy, I found little evidence of "ignorance of the depths in which coral-reefs may form." On the contrary, there appeared to be a remarkable concurrence of testimony on the part of observers that, though occasionally a reef-building species may be found alive at depths greater than about 25 fathoms, this bathymetric limit for the growth of reefs, assigned by the earlier observers, is sufficiently accurate for all practical purposes.

It seems, then, to me that, with the evidence before us, the *onus probandi* of the supposition that a reef may commence at any depth which the exigencies of a particular case require, rests on Mr. Guppy (this done, no theory of coral-reef formation is needed—they may grow anywhere). But, till he can establish this hypothetical but fundamental proposition, Masámarhu Island is a fact for Darwin. T. G. BONNEY.

The Turtle-headed Rock Cod.

A RARE specimen of the turtle-headed rock cod (*Glyptauchen panduratus*) has just come into the hands of Mr. J. Douglas Ogilby, of the Ichthyological Department of the Australian Museum at Sydney. This extraordinary fish belongs to the family of the red rock cods. Not many years ago these fishes (the red rock cod and its allies) formed a part of a most miscellaneous collection of species, which, under the general title of *Triglidæ*, included the true gurnards (*Trigla* and *Lepidotrigla*), the flying gurnards (*Dactylopterus*), and the flat-heads (*Platycephalus*). In 1860, however, Dr. Günther wisely separated these fishes from the *Triglidæ*, which family he broke up into four distinct groups. The first of these, named by him *Scorpænidæ*, is that to which the specimen just captured at Sydney belongs. All the *Scorpænidæ* are carnivorous marine fishes, most of which live at the bottom of the sea, and are generally provided with a powerful armature of the head and fin spines; while many possess skinny appendages on the head and body variously developed, which, owing to their resemblance to the fronds of seaweeds, serve the double purpose of enabling them the more easily to obtain their food, and the more effectually to conceal themselves from their enemies. As they are mostly of a small size, this latter point is evidently of no slight value, because, being slow, lazy fishes, they would, without some such means of protection, be unable to cope with their swifter antagonists. Nature has additionally protected this family by enabling it to vary its coloration according to any change of locality which it may be necessary to make, so as, chameleon-like, to fit itself for adaptation to the various phases of life under which it may be called on to exist. The genus *Glyptauchen*, of which the species just received by Mr. Ogilby is the sole representative, was separated in 1860 by Dr. A. Günther from the Cuvierian genus *Apistus*, for the reception of a fish from King George's Sound, Western Australia, described many years ago by Sir John Richardson under the name of *A. panduratus*. It has since been recorded from Port Jackson (Sydney), and the present specimen comes from Manly Beach, a few miles to the north of Port Jackson.

T.

Atmospheric Electricity.

YOUR correspondent, Mr. C. A. C. Bowlker, will, probably, be interested to learn that an electrical discharge, exactly similar to that which he recently experienced on the Glydyr Fawr (? "Elidyr") was described by the late Dr. Mann, and by Mr. F. G. Smith, in the Quarterly Journal of the Meteorological Society for October 1875.

Mr. Smith was engaged in August 1865 in ascending the Linguard Mountain from Pontresina, when his party was overtaken by bad weather. They reached the summit, however, and found, at one end of the ridge of which it consists, a flag-staff tipped with an iron point, and, at the other, a flat metal disk, serving to indicate bearings. Snow was falling, and nothing was visible except mist, but the "otherwise death-like stillness of the spot was broken by a strange, intermittent noise, resembling the rattling of hailstones against the panes of a window. A careful investigation of the cause of this noise soon made it apparent that it proceeded from the flag staff, and was due to the passage of a continuous electrical discharge from the cloud in which the summit was wrapped."

After a time, the party, although, by Mr. Smith's own admission, "alarmed," held their alpenstocks, points upward, in the air, and, at once, each became conscious of an "electrical discharge passing through him, and causing a throbbing in the temples and a tingling in the finger-ends. The noise was still vigorously proceeding when, after three-quarters of an hour's stay, Mr. Smith and his party left the summit."

I called attention to a somewhat similar phenomenon ("An Engineer's Holiday," vol. i. p. 204), which I experienced on crossing the divide separating Central City from Idaho Springs, Colorado, the height of the ridge being 10,000 feet above sea-level.

There was thunder, and "it was raining, but without lightning, as we neared the divide, when I felt a tickling sensation on the backs of my hands. Presuming that a discharge was taking place between our bodies and the cloud, I tried to increase its intensity by holding my wet umbrella, point upwards, above the waggon. This, at once, produced distinct sensations in the hand and arm, the driver remarking, 'Oh! that's common enough here, though many don't know what it is, and others don't notice it.' This man was very nervous about crossing the divide at all while it was thundering, and plainly said if there was lightning he must wait for fair weather."

Possibly, sound might have accompanied this discharge, but the noise of our wheels would have drowned it.

Holmwood, Putney Hill, May 19. DAN. PIDGEON.

Rain-Clouds.

THE rain-cloud which Mr. Abercromby sketches in NATURE of May 2 (p. 12) is often seen in Upper Austria in summer. I have given a rough sketch of these thunder-clouds in the Austrian *Meteorological Journal*, vol. viii., 1873, p. 104.

Vienna, Hohe Warte 38. JULIUS HANN.

THE MUYBRIDGE PHOTOGRAPHS.[1]

MR. MUYBRIDGE is of English birth, a citizen of the Great Republic, and a professional photographer. Long before he applied his knowledge and skill to the subject of instantaneous photography of moving animals and human beings, he had obtained recognition by his work in producing valuable views of Californian scenery, of Panama and the West Indies. In 1872 he made the first lateral photograph of a horse trotting at full speed, for the purpose of settling a controversy among horsemen as to "whether all the feet of a horse while trotting were entirely clear of the ground" at at any one instant of time. It was not until 1877, however, that he conceived the idea that animal locomotion, which was then attracting considerable attention through the experiments of Prof. Marey, of the Collège de France, might be investigated by means of instantaneous photography, with results of value both to the artist and to the naturalist.

Marey's investigations were made by means of elastic cushions, or *tambours*, which were placed on the feet of the moving animal, and connected by flexible tubes to pencils writing on a chronograph. A record of the impact of each foot on the ground was thus obtained, and important information was deduced from these records as to the succession of footfalls and the time-intervals separating them in the various "gaits" of the horse.

Mr. Muybridge proposed to settle this and similar problems once for all by a complete and demonstrative graphic method. He arranged a number of cameras side by side, parallel to the track along which a horse was to be ridden. Each camera was provided with a specially contrived "exposer" (the word suggested by Mr. Muybridge in place of "shutter"), which could be let go by the pulling of a string. The strings connected with the "exposers" were placed across the path of the horse, so that they must be broken by him successively in his passage. At the instant of the breaking of the string, the exposer was brought into play in the corresponding camera, and thus the horse was photographed in a succession of intervals of about 14 inches, representing, according to the rate of progression of the horse, a time-interval of more or less than one-twentieth of a second.

In this way, in 1878, with the wet plates then in use a few sets of horses moving with various gaits were taken by Mr. Muybridge. The results were astonishing and conclusive. They were published at the expense of Mr. Leland Standford, under the title of "The Horse in Motion," and were exhibited in Europe in 1882 by Mr. Muybridge, together with other photographs taken in 1879. The reception which Mr. Muybridge met with on his visit to Paris and London was a great encouragement to him to proceed with his work. Meissonier, the great French painter, was enthusiastic in his admission of the value of the photographs as a guide to the observation required for all true artistic work, and the story goes that a particular attitude of the horse presented by him in one of his best known pictures which had been objected to by the critics as unnatural, was demonstrated by the Muybridge photographs to be perfectly correct. The series of little black *silhouettes*, which were at that time the form in which Mr. Muybridge obtained his pictures, were so contradictory of all preconceived notions as to what were the actual phases of attitude passed through by a trotting or a galloping horse, and so difficult to reconcile with the conventional representations of what is of course a totally different thing, viz. what we see when a trotting or galloping horse crosses our field of vision, that Mr. Muybridge determined on his return to America in 1883 to pursue the subject, and to apply improved methods of photography to the study of the rapid movements of a variety of animals and of man. The new dry plates now made it possible to obtain in exposures of 1/5000 of a second and less an amount of detail which was previously impossible. New automatic methods of registration and exposure were to be employed, larger pictures obtained, and the selected series printed without re-touching by a permanent photogravure process. The funds necessary to carry out this scheme were beyond Mr. Muybridge's own resources, and he for some time failed to obtain the necessary aid from any publisher or scientific institution. A Committee of the University of Pennsylvania thereupon came forward and placed £6000 at Mr. Muybridge's disposal, solely on condition that the first proceeds of the sale of the photographs when ready for publication should be assigned to the reimbursement of this sum. The words of Dr. William Pepper, the Provost of the University, in recording this most worthy action, are remarkable, and ably state that conception of the part of the University in the life of the State which we have so often advocated in these pages. "The function of a University," says Dr. Pepper, "is not limited to the mere instruction of students. Researches and original investigations, conducted by the mature scholars composing its Faculties, are an important part of its work; and in a larger conception of its duty should be included the aid which it can extend to investigators engaged in researches too costly or elaborate to be accomplished by private means. When ample provision is made in these several directions, we shall have the University adequately equipped and prepared to exert fully her great function as a discoverer and teacher of truth."

As a result of the action of the University of Pennsylvania in providing Mr. Muybridge with the means to carry out his experiments, we have a really marvellous set of plates—781 in number—each containing a series of from twelve to thirty pictures representing successive instantaneous phases of movement. About 500 of the plates represent men, women, and children, nude and semi-nude, in successive phases of walking, running, jumping, dancing, bathing, fencing, wrestling, boxing, and other such exercises. The rest of the plates give similar studies of the various gaits of horses, asses, mules, oxen, deer, elephants, camels, raccoons, apes, sloths, and other quadrupeds, as well as of the flight of birds. Many of these photographs have been, this spring, exhibited in London by Mr. Muybridge, projected on the screen by electric light—at the Royal Society, the Royal Institution, the Royal Academy, and the South Kensington Art School. The whole series can now be obtained by those who desire to possess them, and to assist the University of of Pennsylvania by bearing a portion of the expense of their production. Series of not less than one hundred plates are also to be disposed of, and may be seen on application to Mr. Muybridge, who is at present in London.

The interest which these photographs present from the scientific point of view is threefold:—

(A) They, first of all, are important as examples of a very nearly perfect method of investigation by photographic and electrical appliances.

[1] "Animal Locomotion: an Electro-photographic Investigation of Consecutive Phases of Animal Movements." By Eadweard Muybridge. (Published under the auspices of the University of Pennsylvania, 1888.)

(B) They have also a great value on account of the actual facts of natural history and physiology which they record.

(C) They have, thirdly, a quite distinct and perhaps their most definite interest in their relation to psychology.

It seems, indeed, that the most interesting problems which are brought before us in the Muybridge photographs of the galloping horse are not so much those of animal locomotion itself as these, viz. how is it that this (which is demonstrated by the photograph to be the actual series of attitudes assumed by the galloping horse) has given rise through the human eye and brain to the conventional representation with outstretched fore and hind legs? Can the conventional representation be justified? If it cannot, what do we really *see* as opposed to what really *is*? What is the objective fact—the brain-picture—as opposed to the objective fact—the sun-picture? for it is the former which the painter struggles to reproduce. Here, in fact, science and art are absolutely united in one common search after truth.[1] On this subject I hope to say more in a subsequent article.

With regard to the method and apparatus employed by Mr. Muybridge in the present series of photographs, it is to be noted that they are different from those employed in 1878–79. As in his earlier photographs, so in the later series, Mr. Muybridge's object was to obtain successive clear and separate pictures. In this respect his method differs altogether from the simpler and much cheaper one used by Marey since the publication of Muybridge's first results. Marey's method is, no doubt, efficient, and in a certain sense sufficient, for the purpose of determining some of the main facts as to the phases of the limbs in locomotion. The object to be studied moves in sunlight before a dark background. A photographic camera faces it. A large disk with one or more openings in it is rapidly revolved in front of the lens. Whilst the opening is passing the lens, the moving object is photographed; then there is darkness in the camera until an opening again passes the lens. The moving object has now a new position, and is photographed anew on the same plate; and so on, again and again, as often as required, or until the object has moved beyond the range of the plate. Thus on the same plate are developed a series of images, readily compared and faithfully depicting phases of the movement studied at definite intervals of time. The advantage of this method consists in the simplicity of the apparatus required; its defect is that with rapidly moving objects the amount of light necessary is not easily obtained together with a sufficiently dark background.

Mr. Muybridge's perfected apparatus consists of three batteries, each of twelve (or more) cameras. One battery is parallel to the track, a second looks up it from behind the moving object, a third faces the moving object. Each camera is provided with a specially contrived "exposer" or shutter (so called) which is "let off" by means of an electric current. The exposure thus given is as small as the 1/5000 of a second. The electric connection is such that in each of the batteries A, B, C, a camera, A1, is exposed absolutely synchronously with cameras B1 and C1. So, too, with regard to cameras A2 B2, and C2, and with the rest up to A12, B12, and C12. Each exposure thus gives a group of three synchronous pictures recording lateral, fore, and hind views of the moving object. The intervals between the exposures of the successive trios of cameras, ABC1, ABC2, ABC3, &c., is determined by the rotation of a wheel carrying a metallic brush in front of a circular plate, on the circumference of which are placed equidistant metal studs, one connected with the wires going to each trio. The circuit is completed by the contact of the metal studs with the moving metallic brush. The wheel can, by a special mechanism, be rotated so that a revolution is effected in one second or in any fraction of a second. During one revolution the twelve studs make contact at equal intervals of time, and twelve groups of three photographs each, exposed for the 1/5000 of a second and separated from one another by one-twelfth of the time occupied by a revolution, are taken. Usually, Mr. Muybridge found it convenient to set the wheel so that it should rotate at such a rate as to give 1/30 of a second between the contact of the twelve studs, but longer intervals were also employed. Behind the track along which the object was made to move was a black screen divided by white threads into squares of about 2 inches to the side. The bright sunlight of the open space was the illuminating agent, no artificial light being sufficiently powerful. A full account of the apparatus will be found by those specially interested in the subject in a book published by Lippincott Company of Philadelphia in 1888, entitled "The Muybridge Work at the University of Pennsylvania—the Method and the Result." Enough has been said here to give an idea of the perfection attained in the apparatus.

With regard to the results, in the form of facts recorded of interest to the naturalist and physiologist, it is not easy to speak in the brief space at my disposal. The branch of inquiry opened out by this method of instantaneous photography is in its infancy, and generalizations of any consequence can hardly be looked for at present. The questions to be answered—the hypotheses which it will be necessary to test—have not yet been formulated. What we have in Mr. Muybridge's published plates is a number of individual studies. By far the most complete investigation is that of the various gaits of the horse, which may be considered as very nearly exhaustive. An interesting generalization which perhaps might have been arrived at without the aid of the camera—but could not have been clearly demonstrated without it—is that the walking gait of all Mammalia is the same, including the quadrupedal crawl of the infant man, and the progression of the sloth as it hangs from a horizontal pole. An apparent exception to this rule is found in the baboon, which instead of extending one pair of "diagonals"[1] simultaneously and then bringing them together beneath the body whilst the other pair is extended, exhibits the simultaneous extension of a lateral pair followed by their approximation whilst the opposite lateral pair are extended. The analysis of various gaits involves many points besides the mere swing of the limbs, the most obvious and important of which are the succession of the footfalls, the weight of impact, and its exact period (which need not coincide with visible contact of foot and ground), the exact mechanical value of the complex stroke given by the limb, and the exact period at which it is applied (which need not altogether coincide with that part of it given by the foot as it leaves the ground). Another factor to be studied is the rotation of the various segments of the limb.

Information and suggestion on these points are furnished by the photographs, but it is by no means to be supposed that it is possible that once for all these problems can be settled by any set of photographs, however elaborate. The turning of the quill-feathers of the bird's wing during the upward movement or recovery of the wing, so that they cut the air instead of pressing it with a broad surface, is one of the prettiest demonstrations which Mr. Muybridge has obtained. That such a movement takes place seems to have been observed by the ordinary man in the remote past, for the word "feathering," applied to the similar movement of an oar in rowing, implies a knowledge of the setting of the feathers in the upward movement of the bird's wing.

[1] Mr. Francis Galton, in NATURE, vol. xxvi. p. 228, has made a valuable suggestion on this subject—which is repeated by Mr. George Snell in the *Century* in 1883—to the effect that the brain-picture consists of a blending of the extreme positions of extension of the hind limbs and the fore limbs, which, although not actually coincident in time, are longest in duration of all the phases passed through.

[1] The "diagonals" are the right fore limb and the left hind limb, and the left fore limb and the right hind limb; the "laterals" are the right fore and hind limbs and the left fore and hind limbs.

Whilst the photographs furnish abundant material for the further study and consideration of the normal movements of a variety of animals and of man, there are some in the series which are especially suggestive of new lines of research. Amongst these are the series illustrating locomotion in man in diseased conditions, such as locomotor ataxia, and lateral sclerosis. A distinct line of scientific inquiry is suggested by those photographs which represent men, women, or children, in the course of movement which is associated with emotion. A new chapter in Mr. Darwin's "Expression of the Emotions" could be written by the aid of some of these series, and a most interesting line of investigation, to be followed up by new photographic analysis, is indicated. Not only is the play of facial muscles connected with the series of emotions of the base-ball player recorded in half a dozen pictures taken between the moment of raising the bat and striking the ball, but in other photographs we have unconscious expression of mental condition exhibited by rapidly transient movements of the whole body. These are especially noticeable in the series of a naked child approaching a stranger in order to offer to her a bunch of flowers, and in the three or four phases of movement of the young woman springing from her bath after she has been unexpectedly "douched" from head to foot with a bucket of ice-cold water.

It is clear enough that the correlation of movements of facial and limb muscles in the expression of emotion can be best studied by such instantaneous photographic series as the Muybridge publication contains; and, as Darwin, with his marvellous insight, showed, such study of emotional states furnishes some of the most important evidence with regard to the relationship of man and animals.

It is no doubt true that the immediate result of Mr. Muybridge's work, from the scientific point of view, is the desire which they evoke to apply this method systematically and experimentally to a variety of subjects of investigation. The present pictures have great value, and many of them great—indeed astonishing—beauty (*e.g.* the wrestling boys). They should be purchased by those who can afford them for the purpose of bearing a share in the expense of so important an experiment as that set agoing by the University of Philadelphia. But we should like to see the batteries turned on again, and a number of new subjects investigated. Terrestrial locomotion has been gradually developed through an amphibious transition from aquatic locomotion. The movements of fishes, of tadpoles, salamanders, turtles, and crocodiles should be included in the scope of any study of vertebrate limb-play. But even more necessary is it that in future the scientific method, of theory, test hypothesis, and experiment, should be followed in the application of the photographic batteries, so that each set of photographs may definitely prove some particular point or points in the orderly development of a general doctrine.

For my own part, I should greatly like to apply Mr. Muybridge's cameras, or a similar set of batteries, to the investigation of a phenomenon more puzzling even than that of "the galloping horse." I allude to the problem of "the running centipede." I have a series of drawings made from large West Indian specimens which I kept alive for some time in my laboratory at University College. At the same time I made drawings and recorded as well as I could the movements of the legs of *Peripatus capensis*, which was also (through Mr. Sedgwick's kindness) living in my laboratory. I am anxious to compare with these movements the rapid rhythmical actions of the parapodia of such Chætopods as Phyllodoce and Nephthys on the one hand, and the curious "gait" of the Hexapod insects, of which Prof. Lloyd Morgan has already written a few words in NATURE. Passing on to scorpions and spiders, and then to shrimps, lobsters, and crabs, we should eventually possess the outlines of an investigation of Arthropod locomotion. There is no doubt that the Muybridge battery would be the one effective means of study in the case of the centipede and marine worms, although in some cases a good deal may be done by intent observation and hand-drawn records. The difficulty of this investigation, and the disastrous results in the way of perplexity which follow from too close an application to it *without* the aid of Mr. Muybridge, is set forth in certain lines, the authorship of which is unknown to me or to the friend who kindly sent them to me on hearing that I was studying the limb-play of centipedes. May I be pardoned for quoting them, and associating in this way fancy with fact, whilst expressing the hope that Mr. Muybridge will take steps to prevent any such catastrophe in the future as these lines record!

> A centipede was happy—quite!
> Until a toad in fun
> Said, "Pray which leg moves after which?"
> This raised her doubts to such a pitch,
> She fell exhausted in the ditch,
> Not knowing how to run.

E. RAY LANKESTER.

ON THE DETERMINATION OF MASSES IN ASTRONOMY.

IN the *Annuaire du Bureau des Longitudes* for 1889 occurs an interesting article by M. Tisserand on the methods employed in the measurement of the masses of the heavenly bodies. The writer begins with an explanation of the elementary principles leading to the law of Newton that *all bodies attract one another with a force which is proportional to their masses and inversely as the square of the distance between them.* He proves, in a popular manner, that this force is equal to the product of mass into acceleration; and therefore, speaking theoretically, to compare the masses of two bodies it is only necessary to apply directly to each of them the same force and to measure the acceleration produced; or, if a body be placed in succession at the same distance from the sun and the earth it will be attracted towards each with a force which is proportional to their masses. Hence, since the space traversed by a body is directly proportional to the acceleration, if during the first second the body fell 330 metres towards the sun, and 1 millimetre towards the earth, it would be obvious that the sun had a mass 330,000 times greater than the earth. Similarly, by applying the law of inverse squares, the relative masses of the sun and earth might be found when the distance of the body from each was not the same. We find that the earth falls towards the sun 10·60 metres in a minute, and that our moon falls towards the earth 4·90 metres in the same time. But the earth is 386 times nearer the moon than it is to the sun, so correcting for difference of distance we get $\frac{4 \cdot 9}{(386)^2} =$ 0·0000328 metre as the fall of the moon towards the earth in a minute. Therefore the sun's mass is to the earth's mass as 10·6 is to 0·0000328—that is, 1/323,000. This method is, however, dependent on our knowledge of the distance of the sun and moon. The same calculation may be employed, without modification, to find the mass of a planet having a satellite. Kepler's third law is used for expressing the mass m of a planet in terms of the sun's mass M. The formula being:—

$$\frac{m}{M} = \left(\frac{a'}{a}\right)^3 \left(\frac{T}{T'}\right)^2,$$

where a is the semi-major axis of the planet's orbit and T the time of revolution round the sun; a' and T′ representing similar terms for the satellite.

In the case of Jupiter, observations of the four satellites may be made and the mean result taken. A recent determination by M. Schur gives the value 1/1047·232 as compared with the sun.

Saturn's mass has been obtained from observations of its two largest satellites, Titan and Japetus. Bessel's researches made it 1/3502, whilst Struve found a value 1/3498. This gives roughly the fraction 1/3500 as the planet's mass.

Newcomb deduced, from observations of the four satellites of Uranus, a mass 1/22,600, and by observations of Neptune's one satellite found a value 1/19,380 as the planet's mass.

Before the discovery of the Martian satellites by Hall, the mass of the planet was a matter of great uncertainty. The discoverer's observations of the satellites led him to assign 1/3,100,000 as the mass of Mars, a result probably not far from the truth.

The Masses of Planets without Satellites.

For the determination of the masses of Mercury and Venus a different and much less exact method of procedure is used. If the masses of Venus and the earth were known, the perturbations they would give to the motion of Mercury could be easily calculated. Let the orbit be calculated which Mercury would have if it existed alone with the sun, and then let its true path be found. By comparing the two paths the disturbing effect of Venus and the earth may be also found. In a similar manner the calculated and true paths of Venus may be compared; the disturbing masses being Mercury and the earth. In this way a series of equations is obtained from which the masses of Mercury and Venus may be isolated. The result in the case of Mercury is 1/5,000,000.

The Mass of Jupiter.

M. Tisserand gives a full discussion of the methods of determining Jupiter's mass, which, being so considerable, shows itself in its effects upon many bodies of our system.

Beginning with comets, he quotes the comet of Lexell as a typical case. In 1769 this comet approached very near to Jupiter, and by the planet's action was brought within our range of vision and given a period of $5\frac{3}{5}$ years. Its return in 1776 could not be observed, and before another revolution could be completed, viz. in 1779, the comet was shown by Lexell to have again approached very near to Jupiter, nearer than the fourth satellite. The probable result was that the elliptic orbit was transformed into a parabolic one by the predominance of the planet's attraction over that of the sun, and the comet left our system, never to return.

From observations of the perturbations of Winnecke's comet, M. de Haertl found Jupiter's mass to be 1/1047·175, whilst Faye's comet gave the value 1/1047·788.

Some of the asteroids approach very near to Jupiter, amongst these are (24) Themis, (49) Pales, and (153) Hilda, and from observations of the motion of Themis the planet's mass has been found 1/1047·538. Estimations have also been made by observations of the perturbations of Saturn, but, since the necessary series should cover a cycle of 900 years, and only 120 years are available, the method is not yet very exact. This accounts for the anomalous result 1/1070·5 found by Bouvard in 1821.

It is also mentioned that Airy, from 1832 to 1836, observed the motion of the fourth satellite and found for Jupiter a mass 1/1047·64, whilst Bessel in 1841 found 1/1047·905.

The following are the masses of the planets given by M. Tisserand, with the earth as unit:—

Mercury	$\frac{1}{16}$	Jupiter	310
Venus	$\frac{4}{5}$	Saturn	93
The Earth ...	1	Uranus	14
Mars	$\frac{1}{10}$	Neptune	17

Cavendish's method for determining the mean density of the earth is next explained, and it is shown that, knowing the relative masses of the planets as given in the above table, we may express their weights in pounds.

Determination of the Masses of Asteroids.

Some pages are devoted to a discussion of these small bodies. It has been found that the effect of each asteroid is to give a motion to the line of apsides of Mars's orbit. The sum of these effects is the same as would be produced by taking a mean orbit of all the asteroids and distributing them uniformly in it. Leverrier made a calculation on the assumption that the total mass of the asteroids was equal to that of the earth, and he found that, if they had a mass only equal to one-fourth that of the earth, Mars would be disturbed by an amount clearly perceptible to us. M. Swedstrup has found the assumption too high, and has calculated that the sum of all the asteroids known up to August 1880 is only about 1/4000 of the earth's mass, or about 1/50 that of the moon. Three comparatively large asteroids have had their diameters measured. Sir W. Herschel found the apparent diameter of Ceres and Pallas to be 0″·35 and 0″·24 respectively; the equivalent in kilometres being 250 and 170. For Vesta, Mädler found an apparent diameter 0″·65, or 470 kilometres. If these bodies be supposed to have the same density as the earth, their proportional masses will be found—Ceres, 1/130,000; Pallas, 1/420,000; Vesta, 1/20,000. By photometric means, the diameters of these asteroids have been determined by Prof. Pickering, and also of some much smaller, such as Eve, with a diameter of 23 kilometres, and Menippe, whose diameter is only 20 kilometres, being no larger than the meteorites met by the earth daily.

Determination of the Masses of Satellites.

The method of determining the mass of our satellite based upon the fact that it is the common centre of gravity of the earth and moon, and not the earth itself, which moves in an elliptic orbit round the sun, is fully explained by the writer. By means of it, the mass of the moon has been found 1/81 that of the earth. Observations of the proportion of lunar to solar precession, as well as lunar and solar tides, also furnish a means of determining the moon's mass.

Masses of Jupiter's Satellites.

These bodies, so proportionally small, the greatest being only 1/10,000 of the planet's mass, cannot have their masses accurately determined by the measurement of the angle subtended by the line joining the planet to the common centre of gravity; for, since the line joining the planet to its satellite is divided into parts inversely proportional to their masses in order to find this point, the line in question is very small. Hence the best method of determining the measures of the satellites in this case is, according to M. Tisserand, by measurement of the disturbances upon each other. This method was propounded and worked out by Laplace with the following results, in terms of Jupiter's mass:—

1st satellite ...	1/59,000	3rd satellite ...	1/11,000
2nd ,, ...	1/43,000	4th ,, ...	1/23,000

This proportion would give the third satellite a mass about double that of our moon.

The Satellites of Saturn.

Titan, as its name suggests, is the largest of the family, and consequently exercises a considerable influence over the others. Prof. Hall found that under its action the major axis of Hyperion's orbit made a complete revolution in about eighteen years. Newcomb, Tisserand, Stone, and Hill have each investigated the matter, but it is mainly due to the two latter observers that Titan's mass has been found 1/4700 that of Saturn. Prof Pickering has compared the diameters of the other satellites with that of Titan by photometric means, and, if they all have the same density, the following numbers represent their masses, Saturn's mass being unity :—

Mimas ...	... 1/500,000	Rhea ...	... 1/32,000
Enceladus	... 1/270,000	Hyperion	... 1/1,800,000
Tethys ...	... 1/75,000	Japetus	... 1/110,000
Dione ...	... 1/85,000		

The mass of Saturn's rings has been found 1/620 that of the planet by observations of the rotational movement which it imparts to the major axes or line of apsides of the satellites.

The masses of the satellites of Uranus and Neptune are not known to any degree of accuracy. The two satellites of Mars have had their masses deduced from photometric measures, but they are so small—about 10 kilometres in diameter, being no larger than the smallest known asteroids—that the numbers found cannot be very exact.

Masses of some Stars.

M. Tisserand rightly gives a dissertation, full and clear withal, of this subject. Sir William Herschel was the discoverer of the relative motions of binary stars in 1802. The obvious conclusion from such a discovery was that the laws of gravitation were universal. Truly, it was not logical to make such an assumption, and some objections have been raised, but the *onus probandi* rests with those who doubt it. In considering the motions of the components of a binary star system, it must be remembered that they revolve round a common centre of gravity. It is usual, however, to consider the principal stars as fixed, but augmented by the mass of its satellite, the latter having an orbit which is the mean of the two. Knowing the fall of the satellite to its primary in one second, we may calculate what it would be if at the same distance from it that the earth is from the sun. But we know by how much the satellite would fall towards the sun, since it would fall as the earth. Hence the consideration of the two falls will give the sum of the masses of the stars in terms of the sun's mass.

The following is the formula employed :—

$$\frac{m + m'}{M} = \left(\frac{a}{p}\right)^3 : T^2 ;$$

m and m' are the masses of the two stars ; M that of the sun ; a is the angle, expressed in seconds, which is subtended at the earth by the semi-major axis of the satellites orbit ; p is the "annual parallax" of the binary group expressed in seconds ; whilst T is the time in years of one revolution of the satellite. These are the numbers that have been obtained for four groups, the distances of which from the earth are known :—

Star.	Parallax.	Magnitude.	Sum of Masses.
α Centauri	0″·80	1	1·8
η Cassiopeiæ	0″·15	4	8·3
70 ρ Ophiuchi	0″·17	4·5	2·5
o^2 Eradini	0″·22	4·5	1·0

Sirius and its Companion.

The article concludes with a complete history of the work which suggested the existence of a companion to Sirius. Bessel had determined the proper motion of thirty-six stars by observations of their right ascensions and comparing with Bradley's, but he found that in the case of Sirius the hypothesis of a uniform variation was irreconcilable with them, and suggested that the irregularities might be produced by the action of some obscure body. As a proof that obscure bodies exist in the heavens, the case of Tycho Brahé's Nova is quoted, this being a star which suddenly appeared in Cassiopeia in 1572, and then gradually disappeared without change of place. After Bessel's death Peters found that it was possible to account for the irregularities by the supposition that Sirius described an orbit in fifty years whose eccentricity was about 0·8. Safford, in 1861, from a discussion of the declinations of Sirius, came to the same conclusion as Peters ; whilst Auwers, in 1862, after investigating about 7000 right ascensions and 4000 declinations, found the time of revolution to be forty-nine years, and the eccentricity 0·601. At the same time as Auwers was engaged with his calculations, Alvan Clark discovered a small star only about 10″ from Sirius, which appeared to be the companion. Future considerations supported the surmise, and proved that this body was precisely what was required to account for the orbit of Sirius round the common centre of gravity.

If Gill's measure of the parallax of Sirius be taken as correct, viz. 0″·38, the sum of the masses of the two stars is equal to 4·4 that of the sun. Sirius has about twice the mass of its companion, and they are separated by a distance a little more than twice the distance of Uranus from the sun.

From a discussion of similar little irregularities in the proper motion of η Cassiopeiæ, Struve found its mass to be 6·6 compared with the sun, whilst its companion was 1·7 times as great.

A reflection on the inability of astronomers before Copernicus to make such measurements as those preceding, concludes this retrospect.

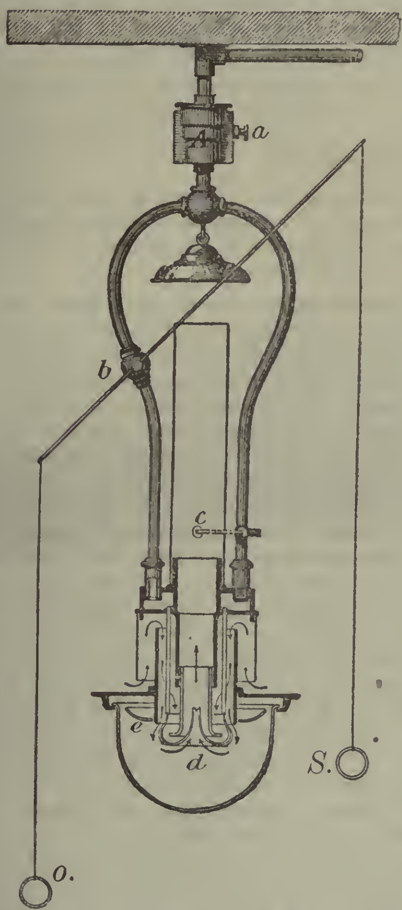
R. A. GREGORY.

A NEW FORM OF REGENERATIVE GAS-LAMP.

FROM the time when Mr. Frederick Siemens first introduced regenerative gas-burners, now ten years ago, down to the present day, this method of burning gas for illuminating purposes has been adopted all over the world, and has come to the assistance of the gas companies by illustrating the fact that, with proper appliances, gas can produce the same brilliant effects as are ordinarily produced by means of electricity, at much less expense both as regards first cost and working. We would explain that in regenerative lamps the heat which is usually wasted in ordinary burners is to a great extent returned to the flame. The manner in which this result is brought about is by intercepting, by means of a regenerator, the heat passing away with the products of combustion, and applying the heat thus saved to raise the temperature of the air which feeds the flame, thus increasing the temperature of the latter, and its illuminating power ; for it may be admitted that the higher the temperature of a body rendered incandescent by heat, the greater is the proportion of light rays emitted out of the total amount of energy radiated. This being the case, the amount of heat carried from such a source of illumination to the surrounding atmosphere by conduction and convection must be less than in the case of a burner consuming the same quantity of gas burning at a lower temperature, which circumstance, combined with the well-known economy resulting from the use of these burners, accounts to a great extent for the popularity which regenerative lamps have attained.

Mr. Frederick Siemens has lately introduced a new form of regenerative gas-lamp, which we understand is highly efficient, and is in consequence being largely adopted ; its construction is shown in the accompanying diagram. It is known as the Siemens inverted type, and is produced in various ornamental designs, which have been much admired. After passing through the governor A, and the tap b, the gas enters an annular casing ; in the lower portion of this, a number of small tubes are fixed, forming the burner, from which tubes the gas passes out in separate streams. By this means, combustion of a very perfect character takes place, as the air is directed round each separate stream of gas, and thus enabled to combine most intimately with it. Within the circle of small tubes is a trumpet-shaped porcelain tube, d, and around the outside and inside of this the gas burns downwards and slightly upwards, as indicated by arrows, thus producing a steady powerful flame of beautiful appearance. This porcelain tube forms the lower portion of the chimney, around which is placed the regenerator. The products of combustion, in passing away, heat the regenerator by conduction, through the metal of the same; and the air, passing upwards and downwards between its metallic surfaces, as also indicated by arrows in the diagram, carries the heat back to the flame. The lamp is closed below by a glass globe, which, however, need not be removed for lighting, as a flash-light is provided for that purpose.

These lamps are made of different sizes, with a consumption varying from 10 to 40 cubic feet of gas per



hour; with London gas they give a light of from ten to twelve candles per cubic foot consumed per hour, which is from four to five times as much as is obtained with ordinary burners. It would have been easy to arrange the lamp we have just described so as to produce a much higher result than that given above; but, to produce this effect, the air supplying the burner would have to be passed through small channels, which would be liable to be partly closed up by oxidation, and thus, by reducing the air-supply, cause the lamp to smoke, whereas the Siemens lamp has been specially designed to provide against this unpleasantness, to which regenerative gas-lamps are more or less liable.

HEINRICH GUSTAV REICHENBACH.

ON the 6th inst., there died at Hamburg, in the sixty-seventh year of his age, a botanist long and familiarly known to his English colleagues, and one whose name will be preserved in the annals of botany.

Heinrich Gustav Reichenbach had been Professor of Botany and Director of the Botanic Garden at Hamburg since 1862. He was born in Leipzig, his father having been also a well-known botanist and Professor in Dresden from 1820 till his death in 1879. Much of the younger Reichenbach's work was done in association with his father, with whom he co-operated in the production of the later volumes of the carefully elaborated *Icones Floræ Germanicæ et Helveticæ*. But work of this character, carefully and critically executed though it was, was cast into the shade by the magnitude of his labours among the Orchidaceæ. Reichenbach the younger devoted more than forty years of his life, almost (though, as we have seen, not quite) exclusively to the study of orchids.

At the commencement of his career, Lindley was still in the plenitude of his powers, but when, some quarter of a century since, the great English botanist failed in health, and subsequently died, there was no one to question the supremacy of Reichenbach so far as orchids were concerned.

From that time to the present the Hamburg Professor has reigned with undisputed sway. His reign corresponds in its progress with the development of that passion for the cultivation of orchids which has attained such large proportions in this country. This is a fashion which at present shows no sign of waning here, whilst it is spreading widely in other countries. It has proved of signal service to orchidology in its systematic aspect, and to a less degree to morphology and biology, as witnesses, to cite only one illustration, the work of Darwin on the "Fertilization of Orchids." A hundred years ago about three hundred species were catalogued in the later editions of Linnæus's "Species Plantarum," and those three hundred were very imperfectly known or illustrated. About sixty years have elapsed since Lindley began his first systematic enumeration of the genera and species, a work in which he was at first greatly aided by the previous labours of Brown and by the splendid drawings of Bauer. In 1840, at the conclusion of the "Genera and Species," Lindley mentions that the total number of species included in that work amounted to 1980, of which the author himself had analyzed three-fourths. Later estimates in the "Vegetable Kingdom" bring the numbers up to 394 genera and 3000 species. Bentham, in 1883, calculated the known species as between 4500 and 5000; while Pfitzer, the most recent census-maker, gives the extreme number of species as 10,000. Granting that this latter figure is excessive, it at least suffices to illustrate the enormous increase in our knowledge of orchids. This advance has been, as we have said, chiefly due to the orchidomania which originated as a consequence of the exhibition of a few remarkable forms at the early meetings of the Horticultural Society, and which has been growing ever since. We never heard of any material good arising from the tulipomania; but the passion for orchids, involving, as it has done, the exploration of the countries where they grow, and the collection and transmission of countless thousands of specimens, live and dead, not only of orchids but of plants of other orders also, has most undoubtedly been of great service to botany, and it has served also to illustrate the great, but often unappreciated, value of gardens as instruments of scientific research. Dried specimens of orchids afford a sorry spectacle at best, and the characters upon which the distinction of genera and species depend are readily obliterated or lost in the drying process. But in gardens the material is often ample, and in the best condition for examination.

Reichenbach, as we have seen, was able to avail himself to a much larger extent than any of his predecessors of the facilities offered by gardens. He became the acknowledged referee on all questions of nomenclature, and to him were constantly submitted fresh specimens for examination. Of late years, also, hybridization has been practised to a large extent among orchids, and the resultant hybrids found their way to Hamburg, there to be compared with the parental forms from which they had emanated. The result of this correspondence with orchid-growers of all classes in all countries, as well as with collectors and botanists, was that the Hamburg Professor became the depositary of the greatest amount of orchid-lore yet accumulated, and the possessor of the largest stores of materials relating to the order. Unhappily his synthetic faculty was by no means so strong as his acquisitive tendencies were great and as his analytical powers were developed; so that much is left for his successors to accomplish in collating and expounding his work. In no place in the world can this be done so readily as at Kew, so that on all accounts it is earnestly to be hoped that the late Professor's herbarium and notes may find their way to that establishment, where Lindley's collections are already enshrined.

Reichenbach was almost exclusively a systematist. He had little to say on morphological questions, and less on the biological points which lend such great interest to the study of the order. Speculations were made the subject of sarcasm by him, and to the last it may be doubted whether he had any great amount of sympathy with those researches which have furnished the clue to the explanation of the extraordinary and highly diversified structure of orchid-flowers, and illustrated alike its genetic and its physiological significance. Nevertheless, as in his lifetime he was constantly and disinterestedly at the service alike of his brother naturalists and of the orchid-growing community, shrinking from no labour or trouble where an orchid was concerned, so in that future reconstruction of the order on morphological and physiological principles which is inevitable, the botanist, be he who he may, will find himself as much indebted to the labours of Reichenbach, as unable to proceed without constant reference to them, as are the students of the present day. His title to our gratitude is indefeasible; it will be even more so to our successors.

NOTES.

The Croonian Lecture, "Les Inoculations Préventives," will be delivered at the Royal Society to-day, by Dr. Roux, of the Pasteur Institute, Paris.

The ship *Hvidjörnen* arrived at Copenhagen on May 21 from Greenland, having on board Dr. Fridtjof Nansen and his companions, who succeeded in crossing Greenland from east to west on snow shoes. The members of the expedition received an enthusiastic welcome from a large crowd.

The anniversary meeting of the Royal Geographical Society, for the election of President, Council, &c., will be held in the hall of the University of London, Burlington Gardens, on Monday, May 27, at 2.30 p.m., General R. Strachey, F.R.S., C.S.I., President, in the chair. After the presentation of the Royal medals for the encouragement of geographical science and discovery, the annual address on the progress of geography during the year will be delivered by the President.

An International Congress of Chronometry will be opened at the National Observatory, Paris, on September 7. An influential organizing Committee has been formed, of which Vice-Admiral de Fauque de Jonquières has accepted the presidency. Those who wish to become members should communicate with the secretary, M. E. Caspari.

Congregation has approved of the nomination of Dr. William Huggins, F.R.S., as a visitor of the Oxford University Observatory, in place of the late Dr. Warren de la Rue.

According to the Rome Correspondent of the *Daily News*, the Pope has decreed, owing to the wishes expressed by Padre Denza more than a year ago, that the works for the Astronomical Observatory, to be erected in the Vatican, are to be begun at once. The site selected is the tower over the rooms occupied by the Master of the Sacred College, it being the most elevated building of the Vatican Palace. The cost is estimated at a million of francs.

Mr. W. P. Johnston, Government Electrician, Calcutta, died on April 23, at Darjeeling. According to *Allen's Indian Mail*, Mr. Johnston had served for over twenty years in the Indian Telegraphs, and had specially distinguished himself in the scientific branch of the Department, his researches in connection with duplex telegraphy, the working of river cables and long stretches of land lines, having been unusually productive of good results. He was also one of the first to improve the telephone after its introduction into India.

It is reported in the Chinese Press that the Marquis Tsêng, so well known in Europe as the Ambassador of China to this country, has been appointed to the control of the Foreign Science College in Pekin.

Prof. Milne, of the University of Tokio, whose work in connection with the investigation of earthquake phenomena is well known to all readers of this journal, is in England for a short time on leave of absence.

Dr. John Gibson, who has for some time been engaged in superintending the physical work of the Fishery Board for Scotland, has recently completed a series of investigations which are likely to throw considerable light on the problems connected with ocean currents. The detailed results will appear in the next Annual Report of the Fishery Board; but from a preliminary note communicated to the Royal Society of Edinburgh it appears that two chemically distinct kinds of sea water are present in the North Sea. The difference between these two waters is rendered perfectly distinct by sufficiently accurate determinations of the relation between chlorine and density, and is not due to river water flowing into the North Sea. Water in which the relative proportion of chlorine is high reaches the North Sea from the surface of the Atlantic, round the north of Scotland and also through the English Channel, while water in which the relative proportion of chlorine is low flows into the North Sea from the north, and has been found on the surface as far north as 79° N. lat. The determinations of chlorine and density in the samples of ocean water collected during the *Challenger* Expedition, as published in the *Challenger* Reports, seem to show that similar differences of composition exist in ocean waters. To judge from these determinations, the mass of ocean water, especially in southern latitudes, approximates in chemical composition to that flowing as above mentioned into the North Sea from the surface of the Atlantic. The water in which the relative proportion of chlorine is less appears to have been met with chiefly to the north of the equator and to the south-west of the principal outlets from the Arctic Ocean. This, as well as its chemical composition, seems to point to an Arctic origin.

A severe earthquake occurred at Plevlje, in Bosnia, at 3.43 a.m., on May 8. It lasted three seconds, the direction of the shocks being from west to east.

Several shocks of earthquake occurred on April 26 in Schwyz, and at Schaffhausen and Wilchingen.

On May 20 a waterspout burst over the district of Crimmitzschau, in Saxony. Two persons were drowned at the town of that name, and a third at the neighbouring village of Lauterbach.

The British Consul at San José, in Costa Rica, in his latest report says that a Meteorological Institute has been established at San José, and several useful observations have been taken, especially of recent earthquakes. He adds that the year 1888 did not have a very propitious closing, for just two days before the end of the year, the capital and surrounding districts were visited with several severe shocks of earthquake. The first shock took place on December 29 at 8 p.m. This was followed by another at 11 p.m., and on Sunday, December 30, at 4.21 a.m., by the most severe of all, lasting 25 seconds, and of such force as to cause considerable damage to the principal buildings in San José, and to nearly all the churches, besides private houses, few of which escaped damage. The morning was pitch dark, and hundreds of people, in all kinds of costumes, hurried into the Central Park looking for their friends, not knowing what might happen or whether any portion of their houses would be left to them. Several houses have been condemned by the authorities, and have had to be pulled down, whilst energetic measures are being taken to repair the damage done to the principal buildings, and the Government have erected temporary shelters for the poor who have been rendered homeless. The total damage is estimated at half a million sterling.

THE half-yearly meeting of the Council of the Italian Meteorological Society was held on April 28. Padre Denza referred to the activity of the Society during the previous six months, during which time several observing stations had been added in Italy and at Malta and Punta Arenas (South America); and to the working of the hygienic stations established at Florence and several other important cities. He also referred to the various Conferences which are being held in accordance with the decisions of the general meeting at Venice last year, for the purpose of popularizing meteorological science in Italy. Special investigations are being carried out with the view of determining the amount of carbonic acid gas in the air, and with regard to the system of the winds in the South Atlantic. The questions of sunshine and phenological observations were also discussed, and the importance of issuing general instructions for these subjects, and for the regular geodynamical observations at the Society's stations.

AT the meeting of the Scientific Committee of the Royal Horticultural Society on May 14, Mr. Wilson made some remarks on the question of the protection of fruit-trees against winter moths. He observed that the plan recommended in the *Agricultural Gazette* of October 15, 1888, of making a ring of cart grease and Stockholm tar round the bases of fruit-trees, though very effectual in catching large quantities of wingless females, had not prevented them from attacking the trees altogether, as the leaves on certain trees thus treated (as described at the Scientific Committee on January 15, 1889) were all going at the present date. At the same meeting Dr. Masters exhibited several photographs of plants from Madeira, including one of *Phytolacca dioica* as a large tree with a massive base of confluent roots, the usual form of this plant in Europe being a herb.

AT the last meeting of the Chemical Society of Göttingen, Dr. Buchka announced the results of his investigations upon the composition of bromide of sulphur. Balard long ago showed that sulphur readily dissolves in bromine with formation of a ruby-red liquid; this liquid, as more recently shown by Mr. Pattison Muir, may be freed from excess of bromine by means of a current of dry carbon dioxide. On attempting, however, to subject it to distillation, it is found to boil at about 200° C., but with decomposition. Indeed it is possible, by repeated distillation, to completely dissociate it into sulphur and bromine. Hence it has never hitherto been possible to analyze a sample of the redistilled liquid, and so there has been a certain amount of doubt as to its composition. Most of the analyses hitherto published have pointed to the formula S_2Br_2, but Guyot ascribes to it the formula SBr_2. Hence Dr. Buchka has attempted the distillation of the crude product under diminished pressure, and finds that the experiment entirely succeeds at the low pressure of 20 mm. of mercury, the red liquid passing over without the least sign of decomposition at a temperature of 111°–113°. Analyses of this redistilled liquid confirm the formula S_2Br_2. Hence bromide of sulphur resembles the monochloride, S_2Cl_2, the most stable of all the chlorides of sulphur: it differs from the chloride, however, in being more unstable, and only volatilizable without decomposition at a pressure not much exceeding 20 mm. of mercury.

FORMALDEHYDE, CH_2O or $H.COH$, the first member of the important series of aldehydes, has been synthesized by Prof. Jahn, of Cronstadt, Hungary, in a most instructive manner. During the course of Dr. Jahn's well-known researches upon the volumetric estimation of hydrogen by means of palladium, it was noticed that the presence of carbon monoxide always considerably disturbed the occlusion of the hydrogen by the palladium. As there was a possibility that some of the hydrogen had bodily united with the carbonic oxide with formation of formaldehyde, it was determined to repeat the experiment upon a larger scale and in a more suitable form of apparatus. A mixture of carbon monoxide and hydrogen was therefore led over a layer of spongy palladium, and the products passed through a series of bulbs containing water. On detaching the bulbs the odour of aldehyde was readily perceived, and the contents at once reduced an ammoniacal silver nitrate solution with formation of the silver mirror characteristic of aldehydes. Hence it was quite evident that the carbon monoxide and hydrogen had partially united in the pores of the palladium with production of formaldehyde. Two litres of the mixed gases were found quite sufficient to give a good silver mirror. This reaction is all the more interesting in view of Dr. Loew's recent synthesis of formose, $C_6H_{12}O_6$, an artificial member of the glucoses, by condensation of formaldehyde with calcium hydroxide; for as carbon monoxide is readily prepared by passing oxygen over excess of heated carbon, it may be said that glucose has been built up directly from its elements—carbon, hydrogen, and oxygen.

THE officials of the Australian Museum, Sydney, are now engaged in working at the Percoid Fishes, and the trustees announce that they will be glad to make exchanges in this group with the authorities of other museums.

THE Paris Correspondent of the *Daily News* says the Zoological Society of France has warned the French Government that a great ornithological calamity is impending. The Department of the Bouches du Rhône has hitherto been one of the chief landing-places for swallows coming from Africa. Engines for killing them, formed of wires connected with electrical batteries, have been laid in hundreds along the coast. When fatigued by their over-sea flight, the birds perch on the wires and are struck dead. The bodies are then prepared for the milliner, and crates containing thousands of them are sent on to Paris. This has been going on for some years, and it has been noticed this spring that swallows have not landed on the low-lying coast, but have gone farther west or east, and that they go in larger numbers than formerly to other parts of Europe. There are places, says the Zoological Society in its petition, where they used to be very numerous, but which they have now deserted, although there has been no falling-off in the gnats and other flying insects on which they live.

MISS E. C. JELLY, F.R.M.S., proposes to issue shortly a catalogue of the published species of recent Polyzoa, with a full synonymy. The main lines followed are those of Hincks and Waters. Only a limited number of copies will be printed, and application for them must be made to the authoress.

THE State University of Iowa has begun to issue what promises to be an excellent series of Bulletins from its laboratories of natural history. No systematic biological survey of the State has yet been attempted, and the editors of the new

Bulletin do not suppose that it will be in their power to provide such a survey. They propose, however, to bring before their readers some idea of the natural history of Iowa, and of the manner in which it may be studied; hoping in this way to stimulate an interest in such things sufficient to lead to greater results in the future.

AN interesting note, by Mr. Arthur A. Rambaut, on some Japanese clocks lately purchased for the Dublin Science and Art Museum, has been reprinted from the Proceedings of the Royal Dublin Society. These clocks, though differing in other respects, agree in this particular, that the time is recorded, not by a hand rotating about an axis, but by a pointer attached to the weight, which projects through a slit in the front of the clock-case. This pointer travels down a scale attached to the front of the clock, and thus points out the hour. Mr. Rambaut has consulted several persons who have been resident for some time in Japan, but none of them has ever seen clocks of like construction in actual use. A young Japanese gentleman to whom the specimens have been shown, says that he has heard of such clocks being used in rural parts of Japan about twenty or thirty years ago, but that they have been almost completely superseded by clocks made on the European plan.

THE fact of intermittence in the intensity of some sensations is known to physiologists. Thus, the tick of a watch withdrawn gradually from the ear begins to be heard, by turns, distinctly and indistinctly, then times of silence alternate with the sound. M. Couetoux, in the *Revue Scientifique*, calls attention to an analogous experience he has had in the case of vision. Looking at a distant windmill, with four vanes, he could not make up his mind whether it was in slow motion (like a nearer one); for, of the three vanes projected against the sky, he saw now one, now another; but the intermittent degradation of the sensorial impression prevented his observing two successive positions. These sensorial fluctuations seem to deserve careful study.

AT a recent meeting of the Manchester Section of Chemical Industry, Mr. William Thompson read a paper on the heat-producing powers of twelve samples of coal, determined by burning in oxygen (in the apparatus devised by him), compared with their theoretical values as calculated from their chemical composition. The coal which he found to give the highest results as regards heat-producing was anthracite, which gave 8340 Centigrade units of heat. Next came Pendleton coal, with 7736 units; then Wigan coal, 7552; and the lowest of the twelve came from near Atherton, with 6448 units. The results obtained by experiment were higher in two coals than the calculated results obtained by determining by heat units given by the combustion of the carbon, hydrogen, and sulphur found by analysis, but deducting the hydrogen, which appears always to be in combination with the oxygen present, so that its hydrogen does not produce heat on burning. In two coals the heat found by calculation and that found by experiment were the same, and in seven coals the heat found by calculation was greater than that found by experiment. A short discussion followed the reading of the paper.

THE additions to the Zoological Society's Gardens during the past week include a Rough Fox (*Canis rudis* ♂) from Demerara, presented by Mr. James Coombe; a Derbian Wallaby (*Halmaturus derbianus* ♂) from Australia, presented by Mr. Buckland, s.s. *Britannia*; two Great Eagle Owls (*Bubo maximus*), European, presented by the Executors of the late Mr. W. J. Cookson; two Red-legged Partridges (*Caccabis rufa*) from the Canary Islands, presented by Captain Augustus Kent, s.s. *Fez*; six Barbary Turtle Doves (*Turtur risorius*) from North Africa, presented by Major T. Erskine Baylis, F.Z.S.; a Black-bellied Sand Grouse (*Pterocles arenarius* ♂) from India, presented by Mrs. Ayrton Pullan; a —— Falcon (*Falco* sp. inc.) from Australia, presented by Baron F. von Mueller, C.M.Z.S.; a Tuberculated Iguana (*Iguana tuberculata*) from Spanish Honduras, presented by Mr. J. B. Johnson, s.s. *Antilles*; a Grey-breasted Parrakeet (*Bolborhynchus monachus*) from Monte Video, presented by Mrs. Macnab; ten Common Vipers (*Vipera berus*) from Surrey, presented by Mr. C. F. McNiven; two Common Vipers (*Vipera berus*) from Gloucestershire, presented by Mr. Barry Burge; a Chimpanzee (*Anthropopithecus troglodytes* ♂) from West Africa, two Cormorants (*Phalacrocorax carbo*), British, deposited; a Mountain Ka-ka (*Nestor notabilis*) from New Zealand, a Green-headed Tanager (*Calliste tricolor*) from South-East Brazil, purchased; five North African Jackals (*Canis anthus*), a Japanese Deer (*Cervus sika* ♀) a Collared Fruit Bat (*Cynonycteris collaris*), a Great Kangaroo (*Macropus giganteus* ♂), born in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 MAY 26—JUNE 1.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 26

Sun rises, 3h. 56m.; souths, 11h. 56m. 48·8s.; daily increase of southing, 6·5s.; sets, 19h. 58m.: right asc. on meridian, 4h. 13·8m.; decl. 21° 13′ N. Sidereal Time at Sunset, 12h. 16m.

Moon (New on May 29, 17h.) rises, 3h. 2m.; souths, 9h. 36m.; sets, 16h. 24m.: right asc. on meridian, 1h. 52·8m.; decl. 6° 16′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	5 4 ...	13 34 ...	22 4 ...	5 51·4 ...	25 12 N.
Venus.....	2 41 ...	9 47 ...	16 53 ...	2 3·9 ...	11 55 N.
Mars......	4 12 ...	12 23 ...	20 34 ...	4 39·9 ...	22 41 N.
Jupiter....	22 18*...	2 14 ...	6 10 ...	18 29·6 ...	23 3 S.
Saturn....	9 16 ...	16 53 ...	0 30*...	9 11·1 ...	17 27 N.
Uranus...	15 20 ...	20 50 ...	2 20*...	13 8·3 ...	6 34 S.
Neptune..	3 58 ...	11 45 ...	19 32 ...	4 1·5 ...	19 2 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

May.	h.	
26 ...	16 ...	Venus in conjunction with and 4° 30′ north of the Moon.
31 ...	16 ...	Mercury in conjunction with and 1° 53′ north of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m
U Cephei	0 52·5 ...	81 17 N. ...	May 26,	0 30 *m*
			,, 31,	0 9 *m*
R Crateris	10 55·1 ...	17 44 S. ...	,, 27,	*M*
W Virginis	13 20·3 ...	2 48 S. ...	June 1,	1 0 *M*
δ Libræ	14 55·1 ...	8 5 S. ...	May 27,	22 33 *m*
U Coronæ	15 13·7 ...	32 3 N. ...	June 1,	21 0 *m*
U Ophiuchi... ...	17 10·9 ...	1 20 N. ...	May 27,	1 42 *m*
			and at intervals of	20 8
β Lyræ...	18 46·0 ...	33 14 N. ...	May 27,	20 30 *M*
			,, 31,	2 0 *m*
U Aquilæ	19 23·4 ...	7 16 S. ...	June 1,	3 0 *M*
S Vulpeculæ ...	19 43·8 ...	27 1 N. ...	May 28,	*M*
S Sagittæ	19 51·0 ...	16 20 N. ...	,, 29,	2 0 *m*
			June 1,	2 0 *M*
δ Cephei	22 25·1 ...	57 51 N. ...	May 31,	23 0 *M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
	290° ...	60° N. ...	May 30. Short, slow.
From Vulpecula	305 ...	25 N. ...	Swift.
,, Lacerta...	330 ...	48 N. ...	Very swift.
Near ι Pegasi...	333 ...	27 N. ...	Swift, streaks.

BEACON LIGHTS AND FOG SIGNALS.[1]

I.

IT is stated by Samuel Smiles in his "Lives of Engineers" that, "with Winstanley's structure on the Eddystone in 1696, may be said to have commenced the modern engineering efforts in directing the great sources of power in Nature for the use and convenience of man," efforts which, followed up by Rudyerd, Smeaton, and others, have been so successful in converting hidden dangers into sources of safety, and insuring the beneficent guidance of the mariner in his trackless path.

The famous structure of Smeaton, which had withstood the storms of more than half a century with incalculable advantage to mankind, became in course of time a matter of anxiety and watchful care to the Corporation of Trinity House, owing to the great tremor of the building with each wave stroke, during heavy westerly storms. The joints of the masonry frequently yielded to the heavy strains, and the sea-water was driven through them to the interior of the building. The upper part of the structure was strengthened with internal ironwork in 1839, and again in 1865. On the last occasion it was found that the chief mischief was caused by the upward stroke of the heavy seas against the projecting cornice of the lantern gallery, thus lifting this portion of the masonry, together with the lantern above it. Unfortunately, the portion of the gneiss rock on which the lighthouse was founded had become seriously shaken by the heavy sea strokes on the tower, and the rock had thus been seriously undermined at its base. The waves rose during storms considerably above the summit of the lantern, thus frequently eclipsing the light, and altering its distinctive character from a fixed light to an occulting. This matter of distinctive character in a beacon light was one of little importance at the date of the erection of Smeaton's lighthouse, when coal fires were the only illuminating agents along the coasts; but with the rapid development of our commerce, and the great increase in the number of coast lights, it has become an absolute necessity that each light maintain a clearly distinctive character. It was therefore determined by the Trinity House, in 1877, to erect a new lighthouse at a distance of 120 feet from Smeaton's tower, where a safe and permanent foundation was found, but at a much lower level, which necessitated the laying of a large portion of the foundation masonry below low water. The foundation-stone of this work was laid on August 19, 1879, by H.R.H. the Duke of Edinburgh, Master of the Trinity House; assisted by H.R.H. the Prince of Wales, an honorary Elder Brother of the Corporation.

On June 1, 1881, H.R.H. the Master, when passing up the Channel in H.M.S. *Lively*, landed at the rock and laid the last stone of the tower; and on May 18 of the following year H.R.H. lighted the lamps, and formally opened the lighthouse. The edifice was thus completed within four years from its commencement, at a cost of £59,255. The work was executed under the immediate direction of the Trinity House and their Engineer, and with a saving of £24,000 on the lowest sum at which it had been found that it could be executed by contract. Every block of granite in the structure is dovetailed together both vertically and horizontally, on a system devised by my father, and first adopted at the Hanois Rock Lighthouse off the west coast of Guernsey. The illuminating apparatus consists of two superposed oil lamps, each of six concentric wicks, and of two drums of lenses of 920 millimetres focal distance, twelve lenses in each drum. The optical apparatus is specially designed on the system of Dr. John Hopkinson, F.R.S., for a double flashing light, and shows two flashes in quick succession, at intervals of half a minute. Attention has of late been directed to the subject of superposed lights in lighthouses, which became a necessity when several small luminaries had to be substituted for the large coal or wood fire of our early lighthouses. The credit of first superposing lighthouse luminaries is doubtless due to Smeaton, who lighted his lantern, in 1759, with twenty-four large tallow candles in two tiers. The idea was followed in 1790 with the first revolving light, established at the St. Agnes Lighthouse, Scilly Islands, which consisted of fifteen oil lamps and reflectors, arranged in three groups, and in three tiers. The number of the lamps and reflectors at this and other first class lights was afterwards extended to thirty, and in four tiers. In 1859, Mr. J. W. D. Brown, of Lewisham, proposed superposed lenses for signal and lighthouse lanterns, with a separate light for each tier of lenses. In 1872, Mr. John Wigham, of Dublin, proposed superposed lenses for lighthouses, in conjunction with his large gas flames, and the first application of these was made in 1877 at the Galley Head Lighthouse, County Cork. In 1876 Messrs. Lepaute and Sons, the eminent lighthouse optical engineers of Paris, made successful experiments with superposed lenses and mineral oil flames, and one of their apparatus was exhibited at the Paris International Exhibition of 1878. The results of these experiments were given by M. Henry Lepaute, in a paper contributed to the Congress at Havre in 1877, of the French Association for the Advancement of Science. The Eddystone represents the first practical application of superposed lenses of the first order, with oil as the illuminant.

The apparatus at the Eddystone is provided with two six-wick burners of the Trinity House improved type, and has a minimum intensity for clear weather of about 38,000 candle units, and a maximum intensity of about 160,000 candle units for atmosphere impaired for the transmission of light. The chandelier light in Smeaton's lantern was unaided by optical apparatus. I have found by experiment that the aggregate intensity of the beam from the twenty-four candles was 67 candle units nearly. The maximum intensity of the flashes now sent to the mariner is about 2380 times that of the candle beam, while the annual cost for the mineral oil illuminant is about 82 per cent. less.

The sound signal for foggy weather consists of two bells of 40 cwt. each, mounted on the lantern gallery, and rung by machinery. If any wind occurs with the fog, the windward bell is sounded. The distinctive character of the signal is two sounds of the bell in quick succession every half-minute, thus corresponding with the character of the light signal.

The tendency of the curvilinear outline near the base of Smeaton's and of other similar sea towers that have followed it, to elevate the centre of force of heavy waves on the structure, induced me to adopt a cylindrical base for the new lighthouse, which is found to retard the rise of waves on the structure, while it affords a convenient platform for the lightkeepers, and adds very considerably to their opportunities for landing and relief. The Town Council and inhabitants of Plymouth having expressed a desire that Smeaton's lighthouse should be re-erected on Plymouth Hoe, in lieu of the Trinity House sea mark thereat, the Trinity House, who, as custodians of public money, had no funds available for such a purpose, undertook to deliver to the authorities at Plymouth, at actual cost for labour, the lantern, and the four rooms of the tower. These have been re-erected by public subscription on a frustrum of granite, corresponding nearly with the lower portion of Smeaton's tower, and it is to be hoped that it will be preserved by the town of Plymouth as a monument to the genius of Smeaton, and in commemoration of one of the most successful and beneficent works in civil engineering.

It is extremely difficult to estimate, with a fair degree of accuracy, the maximum force of the waves with which some of the most exposed of these sea structures may occasionally have to contend. The late eminent lighthouse engineer, Mr. Thomas Stevenson, F.R.S.E., carried out a long series of experiments with a self-registering instrument he devised for determining the force of sea-waves on exposed structures. He found at the Skerryvore Rock Lighthouse the Atlantic waves there gave an average force for five of the summer months in 1843-44 of 611 pounds per square foot. The average result for the six winter months of the same year was 2086 pounds per square foot, or three times as great as in the summer months. The greatest force registered was on March 29, 1845, during a westerly gale, when a pressure of 6083 pounds, or $2\frac{3}{4}$ tons nearly, per square foot was recorded. After Smeaton had carefully considered the great defect of the building of Rudyerd at the Eddystone, viz. want of weight, he replied that, "if the lighthouse was to be so contrived as not to give way to the sea, it must be made so strong as that the sea must be compelled to give way to the building." Smeaton also had regard to durability as an important element in the structure, for he adds: "In contemplating the use and benefit of such a structure as this, my ideas of what its duration and continued existence ought to be were not confined within the boundary of one age or two, but extended themselves to look towards a possible perpetuity." Thus Smeaton soon arrived at the firm conviction that his lighthouse must be built of granite, and of this material nearly all lighthouses on exposed tidal rocks have since been constructed, while those on submerged sandbanks are open structures of iron, erected on screw piles or iron cylinders. The screw pile was the invention of the late Mr. Alexander Mitchell, of Belfast.

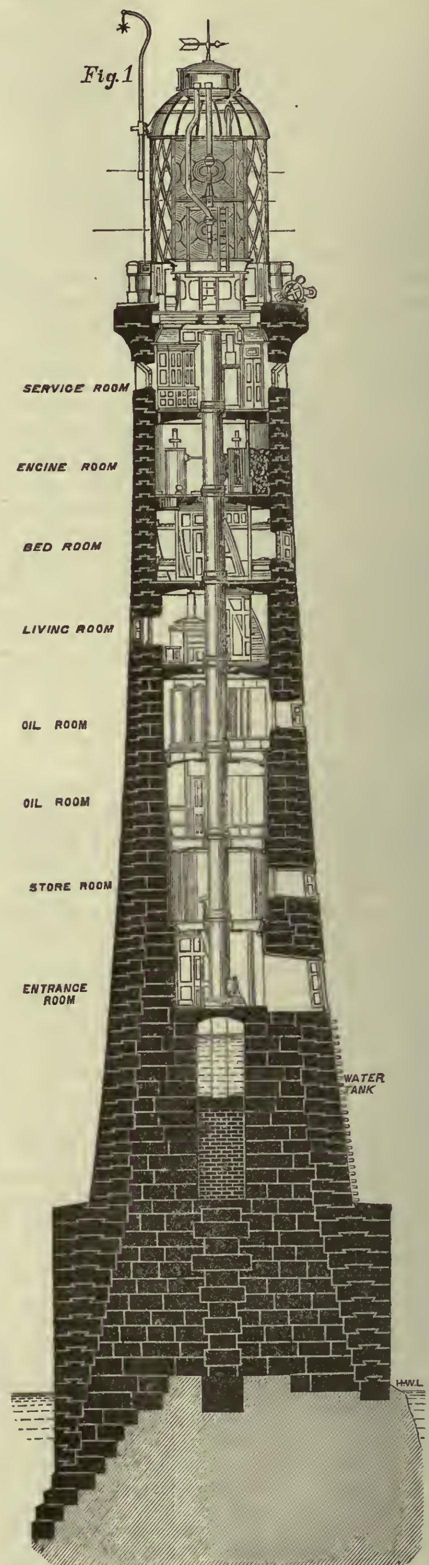
We have here a model of the first lighthouse, erected in 1838,

[1] Friday evening discourse delivered at the Royal Institution by Sir James N. Douglass, F.R.S., on March 15. We are indebted to the Editor of the *Engineer* for the use of the woodcuts illustrating this discourse.

on these screw piles, at the Maplin Sand, on the north side of the estuary of the Thames, under the direction of the late James Walker, F.R.S., then Engineer-in-Chief to the Trinity House. A lighthouse on the principle of minimum surface exposed to the force of the waves, of which we have here a model, was erected on the chief rock of the dangerous group of the Smalls, situated about 18½ miles off Milford Haven, by Mr. John Phillips, a merchant and shipowner of Liverpool. The work was designed, and erected under great difficulties, by Mr. Henry Whiteside, a native of Liverpool, and a man of great mechanical skill and undaunted courage. Added to his mechanical ability, Whiteside possessed a great love and knowledge of music, and had, previous to the erection of his lighthouse, excelled in the construction of violins, spinnettes, and upright harpsicords. The lighthouse, commenced in 1772, was intended to be erected on eight cast-iron pillars, sunk deep into the rock; this material was, however, soon abandoned for English oak, as being more elastic and trustworthy. The work was completed and lighted in 1776 with eight lamps and glass faceted reflectors, similar to the one before us. In 1817 sixteen improved lamps and silvered paraboloidal reflectors were substituted for these; and the lighthouse, although sorely tried by winter storms, was (with the aid of yearly repairs and strengthening) enabled to send forth its beneficent beam until the year 1856, when the Trinity House commenced the erection of a lighthouse of granite, as shown by this model. The vibrations of the old wooden structure must have been very considerable with heavy storms, for the lightkeepers occasionally found it sufficient to cause a bucket of water, placed in the living-room, to spill just half its contents. It was in this lighthouse that the painful circumstance occurred in the year 1802 of the death of one of the lightkeepers. In those days only two men inhabited the lighthouse at a time; one of them was taken ill, and the means employed by his companion for obtaining relief proved ineffectual; he hoisted a signal of distress, but owing to stormy weather no landing could be effected, and after many days of extreme suffering, the poor fellow, named Thomas Griffiths, breathed his last, when the survivor, Thomas Howell, fully realized the awful responsibilities of his position; decomposition would quickly follow, and the atmosphere of the small apartment would be vitiated. The body could not be committed to the sea, as suspicion of murder would probably follow. Howell was a cooper by trade, and he was thus enabled to make a coffin for his dead companion out of boards obtained from a partition in the apartment. After very great exertion the body was carried to the outer gallery, and there securely lashed to the railing. For three long weeks it occupied this position before the weather moderated, yet night after night Howell faithfully kept his lights brightly burning. When a landing was at last effected, his attenuated form demonstrated the sufferings, both mental and physical, he had undergone; indeed, several of his friends failed to recognize him on his return to his home. Since this sad occurrence the Trinity House have always maintained three lightkeepers at their isolated rock stations. The present lighthouse was designed by the late Engineer-in-Chief of the Trinity House, Mr. James Walker, F.R.S., and I had the honour of executing the work as resident engineer. The foundation-stone was laid on June 26, 1857, and the light was exhibited on August 7, 1861. The work was completed by the Trinity House, at a cost of £50,125, being about 24 per cent. under the lowest amount at which it had been ascertained that it could have been executed by contract.

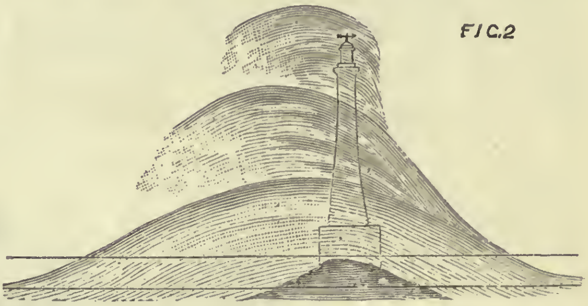
Probably the most exposed rock lighthouse is that on the Bishop (the westernmost of the rocks of Scilly), shown in Fig. 1. Its position is doubtless one of the most important to mariners, warning them, as it does, of the terrible dangers where, on October 22, 1707, Sir Cloudesley Shovel, with the *Association*, *Eagle*, and *Romney*, were lost, with about 2000 men. The Bishop is also the guiding light for the entrances to the English and Bristol Channels. The rock, composed of a very hard, pink-coloured granite, is about 153 feet long by 52 feet wide at the level of low water of spring tides. It stands in over 20 fathoms water, is steep to, all round, and is exposed to the full fury of the Atlantic. It was at first feared that the width of the rock was not sufficient for the base of a stone tower of adequate dimensions to withstand the heavy wave-shocks it would have to resist, and an open structure of wrought and cast iron [shown on the diagram] was determined on. The work was jointly designed by the late Engineer-in-Chief to the Trinity House and my father, the superintending engineer, who afterwards erected the structure, at which I had the honour of acting as assistant engineer.

Fig. 1



The work was commenced in 1847, and at the end of the working season of 1850 the lighthouse was so far completed as to be in readiness for receiving the lantern and the illuminating apparatus, and it was left with confidence to resist the storms of the approaching winter. But during a very violent storm, between 11 p.m. of the 5th and 3 a.m. on the 6th of the following February, the lighthouse was completely destroyed, and swept from the rock. On further consideration of the matter, the Trinity House determined, on the recommendation of their engineers, to proceed with a stone structure, and my father was appointed to build the lighthouse, I acting as before as assistant engineer. The work was proceeded with in the spring of 1851. In order to obtain the greatest possible diameter of base for the tower that the rock would admit of, it was found necessary to lay a portion of the foundation on the most exposed side of the rock, at the level of 1 foot below low water of spring tides; and, although every possible human effort was made by the leader and his devoted band of workers, the foundations were not completed until the end of the season of 1852. Soon after this, my brother, Mr. William Douglass, now Engineer-in-Chief to the Commissioners of Irish Lights, succeeded me as assistant engineer at the work. The lighthouse was completed in 1858, and its dioptric fixed oil light of the first order was first exhibited on September 1 of that year. Soon afterwards, its exposure to heavy seas during storms was fully realized. On one occasion the fog bell was torn from its bracket at the lantern gallery at 100 feet above high water, and the flag-staff, with a ladder, which were lashed outside the lantern, were washed away. The tremor of the tower on these occasions was such as to throw articles off shelves, and several of the large glass prisms of the dioptric apparatus were fractured. After some time it was found that several of the external blocks of granite situated a few feet above high water were fractured by the excessive strains on the building. In 1874 the tower was strengthened from top to bottom by heavy iron ties, bolted to the internal surface of the walls; but, after a violent storm in the winter of 1881, there was evidence of further excessive straining at the face of the lower external blocks of masonry, when the Trinity House, on the advice of their engineer, determined on the re-erection of the lighthouse. This was accomplished (as shown in Fig. 1) by incasing the existing tower with carefully dovetailed granite masonry, each alternate block of the new granite being dovetailed to the old. The work was one of considerable difficulty, owing to the necessity for maintaining the light throughout the progress; and the risk to the workmen was great, especially at the upper part of the old tower, owing to the narrow ledge on which the work had to be executed. I am, however, thankful to state that the new lighthouse has been successfully completed by my son, Mr. W. T. Douglass, who was also my assistant engineer at the Eddystone; and with the same complete immunity from loss of life or limb to any person employed, as with the two previous structures on this rock. The optical apparatus consists of two superposed tiers of lenses of the type adopted at the Eddystone, but of larger dimensions, as suggested by the late Mr. Thomas Stevenson, for obtaining greater efficiency with the larger-flame luminaries recently adopted. The apparatus is provided with two Trinity House improved mineral oil burners, and has a minimum intensity for clear weather of about 80,000 candle units, and a maximum intensity for thick weather of about 513,000 candle units. The character of the light is double-flashing, showing two flashes, each of four seconds' duration, in quick succession, at periods of one minute. The flashes of this light, and those of a light lately completed at about 8 nautical miles from it, on Round Island, are the most intense yet attained with oil flames for beacon lights; and it may be stated that, with no other illuminant at present known to science could these results be carried out within the space available at the Bishop Rock, and under the circumstances attending that work. The fog signal recently adopted at this station, in lieu of the bell, is by the electrical explosion of 4-ounce charges of gun-cotton, at intervals of 5 minutes. The apparatus provided for this form of fog signal is shown in Fig. 1. It consists of a wrought-iron crane (attached to the lantern) which is raised and lowered by a worm-wheel and pinion. When the crane is lowered, its end reaches near the gallery, where the lightkeeper suspends the charge of gun-cotton, with its detonator attached, to the electric cable, which is carried along the crane and through the roof of the lantern to a dynamo-electric firing machine. After suspending the charge, the jib of the crane is raised to its upper position, when the charge is fired nearly vertically over the glazing of the lantern, and thus without causing damage to it. The large and heavy optical apparatus is rotated automatically by compressed air, which is stored in two vertical steel reservoirs, fixed at the centre of the tower. The air is compressed by a small Davey safety motor. A winch, worked by the compressed air, is fixed on the lantern gallery for landing the lightkeepers, stores, &c. Fig. 2 is a sketch, from actual obser-

FIG. 2



vation, of the height and form of waves on the tower during a storm.

The numerous outlying shoals surrounding the shores of this country, particularly off the east coast, were an early cause of anxiety to those responsible for the guidance of mariners. And in addition to buoys as sea-marks by day, floating lights, as guides by night, were found to be a necessity. The first light-vessel was moored at the Nore Sand in 1732, and another near the Dudgeon Shoal in 1736. We have here a model of the latter vessel, from which we may judge of the pluck and hardihood of the crews who manned them, especially when we remember that there were no chain cables in those days, the

Fig. 3

vessel having to be moored with a cable of hemp, which, owing to the constant chafing, occasionally parted during winter storms, when, to save their lives, the crew had to put out another anchor if possible, or set such storm canvas as they could to keep her off a lee-shore, and endeavour to reach a place of safety. The illuminating apparatus of these vessels consisted of a small lantern and flat-wick oil lamps, fixed at a yardarm, and here appears to have occurred the first application of a distinctive character to beacon lights, for the *Dudgeon* was fitted with two lights, one being placed at each arm of the yard (Fig. 3). The next light-vessel was placed at the Newarp Shoal in 1790, and in 1795 one was placed at the north end of the Goodwin Sands.

The two latter vessels were provided with three fixed lights, and the lanterns were larger, and surrounded each mast-head, as shown by the model before us. An improvement was also effected in these lights by providing each lamp with a silvered reflector.

In 1807 the late Mr. Robert Stevenson, the engineer of the Bell Rock Lighthouse, to whom and his successors are due much valuable engineering and optical work connected with coast-lighting, designed a larger lantern to surround the mast, and capable of being lowered to the deck for properly trimming the lamps (Fig. 4). Soon after the adoption of the system of catoptric illumination in lighthouses, it was extended to floating lights; each lamp and reflector was hung in gimbals, to insure horizontal direction of the beams of light during the pitching and rolling of the vessel. We have here one of these apparatus. The intensity of the beam sent from it was 500 candle units, nearly.

On January 1, 1837, the Trinity House installed the first revolving floating light, at the Swin Middle, and later in the same year another, on board the *Gull* light-vessel. The lamps and reflectors were carried on a roller frame surrounding the mast, and rotated through light shaftings by clockwork placed between decks. There were nine lamps and reflectors arranged in three groups, of three each, and thus the collective intensity of each flash was equal to that of three fixed lights, or 1500 candle units, nearly. In 1872 the Trinity House further increased the dimensions of the lanterns and reflectors of their floating lights—the lanterns from 6 to 8 feet in diameter, with cylindrical instead of polygonal glazing, and the reflectors from 12 inches to 21 inches diameter at the aperture. These improvements, together with the adoption of improved burners, have effected a considerable increase in the intensity of these lights; and during the last two years a further improvement has been obtained by the adoption of concentric wick burners with more condensed flames, and of higher illuminating power, by which the intensity of the beam from each reflector has been raised to 5000 candle units, being just ten times the intensity of the smaller apparatus; while, by the adoption of mineral oil in lieu of colza, the annual cost for the illuminant has been reduced 50 per cent.

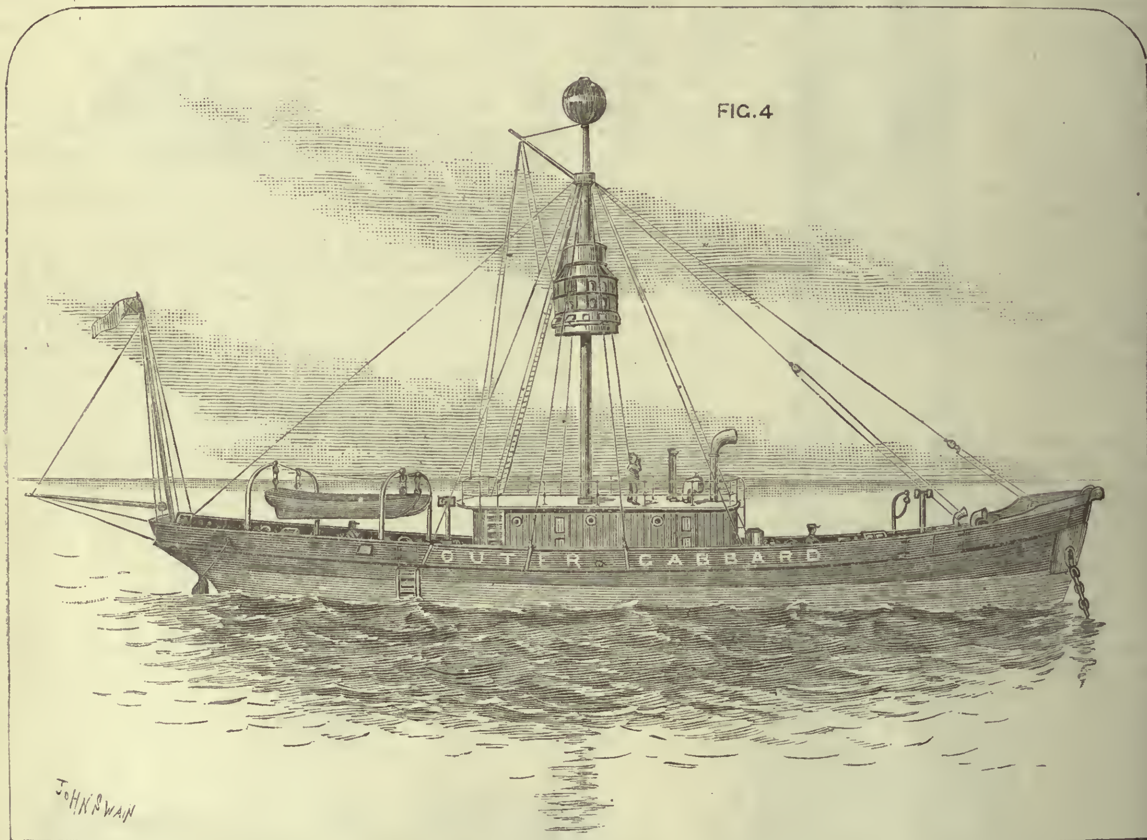


FIG. 4

Dioptric apparatus was proposed for light-vessels by M. Letourneau in 1851, several small fixed-light apparatus being intended to be employed in each lantern, and arranged nearly in the same way as the reflectors. This arrangement has been adopted in some instances by Messrs. D. and T. Stevenson, Engineers to the Commissioners of Northern Lighthouses, and by the engineers of the French Lighthouse Service; but, for efficiency and adaptability to meet the rough duty to which floating lights are occasionally subjected in stormy weather and collisions, this system has been found to be inferior for this service to the catoptric.

An interesting experiment was recently made by the Mersey Docks and Harbour Board with the electric arc light, on board one of their light-vessels, at the entrance of the Mersey; but unfortunately it did not prove successful. The present difficulties experienced afloat with this powerful illuminant will doubtless be overcome, and it will be found to be, as in lighthouses, by far the most efficient illuminant for some special stations, where a higher intensity than can be obtained with flame luminaries is demanded. Experiments have been in progress during the past two years at the *Sunk* light-vessel, off the coast of Essex, for maintaining electrical telegraphic communication with the shore for reporting wrecks and casualties in the locality. This vessel is connected with the post office at Walton-on-Naze, through nine miles of cable. The instruments adopted are the Wheatstone ABC Morse, and the Gower Bell telephone, the telephone for the first time for this purpose on board a vessel at sea, and its efficiency has been found to be so perfect that it is preferred by the operators to the telegraphic instruments. Many difficulties have been experienced in maintaining trustworthy communication during stormy weather, owing to consequent wear and tear of the connections with the vessel, but the system, which was designed and carried out by the Telegraph Construction and Maintenance Company, is now working satisfactorily. Unfortunately, however, it is found to be too costly for adoption except in very special cases.

(*To be continued.*)

A BILL TO PROVIDE TECHNICAL EDUCATION IN ENGLAND AND WALES.

THE following Bill, introduced into the House of Commons by Sir Henry Roscoe on behalf of the National Association for the Promotion of Technical Education, was read a second time without opposition on Wednesday, May 8:—

Whereas it is expedient that due provision should be made for technical education in public elementary schools and elsewhere:

Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1. This Act may be cited as the Technical Education Act, 1889.

2. (1) After the *passing of this Act* any school board may make provision for giving technical education in any school under their management, and either by day or evening classes, or both, as may seem fit, having regard to the daily occupations of the persons to be benefited thereby.

(2) If no such provision is made, or if it is insufficient, and if the local authority by special resolution determine that provision or further provision ought to be made, they may themselves make such provision.

3. Where technical education is given in any school, not being a public elementary school (including for the purposes of this section any college), which is not under the management of a school board or local authority, and is either within their district or accessible to the inhabitants thereof, the school board or local authority may contribute or they may join together with other school boards or local authorities in contributing from their respective funds towards—

(*a*) the maintenance or improvement of that school or of its provisions for technical education; or

(*b*) the payment of the fees at that school of deserving students who before proceeding to such school have been resident in the district of the contributing board or authority;

(*c*) the establishment of scholarships for deserving students.

The mode in which and the terms upon which contributory school boards and local authorities shall be represented upon the governing bodies of schools receiving such contributions, so far as technical instruction is concerned, shall be such as may be agreed upon between the school boards, local authorities, and governing bodies respectively in each case.

Every such contribution shall be deemed to be expenses of such school board or local authority incurred for the purposes of this Act.

4. (1) *Where any school in which technical education is given in pursuance of this Act is also a public elementary school, a parliamentary grant may be made to such school by the Education Department and by the Science and Art Department, or by either of such Departments.*

(2) *The conditions required to be fulfilled by such school in order to obtain an annual parliamentary grant shall be those contained in minutes issued by the Committee of Council on Education.*

(3) Any minute made in pursuance of this section shall not come into force until it has lain on the table of both Houses of Parliament for one month.

5. (1) *Where any school in which technical education is given in pursuance of this Act is not a public elementary school, a parliamentary grant may be made to such school by the Science and Art Department, subject to such conditions as that Department may prescribe.*

(2) Any minute made by the Science and Art Department in pursuance of this section shall not come into force until it has lain on the table of both Houses of Parliament for one month.

6. (1) All the provisions of the Elementary Education Acts relating to the powers of school boards with respect to sufficient accommodation, fees, the combination of school boards, and the acquisition of land, shall apply to school boards in whose schools technical education is given, or to be given, under this Act; and a school shall not cease to be a public elementary school within the meaning of the Elementary Education Acts by reason of technical education being given therein.

(2) A school which is under the management of a school board, and in which technical education is given under this Act, shall be conducted in accordance with the same regulations as an elementary public school under the Elementary Education Acts: Provided, however, that every such school shall be open to the inspection of any inspector appointed by the Department of Science and Art, as well as of Her Majesty's inspectors as defined in the Elementary Education Acts.

7. The expenses incurred by any school board in carrying this Act into effect, including any contributions made by the school board in aid of technical education in schools not under their management, shall be deemed to be expenses of the said school board within the meaning of the Elementary Education Acts, and payable accordingly.

A school board shall have the same powers of borrowing for the like purposes, but subject to the same consent and other conditions, as they have under the Elementary Education Acts.

8. The expenses incurred by a local authority in giving effect to this Act, including any such contributions as are abovementioned, shall be payable out of the local rate. The local authority shall have the like powers of borrowing for the purposes of this Act, but subject to the same conditions, as for other purposes.

9. The provisions of this Act with respect to a local authority shall not apply to the Metropolis.

10. It shall be competent for any school board or local authority, should they think fit, to institute an entrance examination in reading, writing, and arithmetic for persons desirous of attending technical schools or classes under their management, or to which they contribute.

11. For the purposes of this Act the expression "technical education" means instruction in—

(i.) Any of the branches of Science and Art with respect to which grants are for the time being made by the Department of Science and Art.

(ii.) The working of wood, clay, metal, or other material for the purposes of art or handicraft.

(iii.) Commercial arithmetic; commercial geography; modern languages; book-keeping, and shorthand.

(iv.) Any other subject applicable to the purposes of agriculture, trade, or commercial life and practice, which may be sanctioned by a minute of the Department of Science and Art made on the representation of a school board or local authority that such a form of instruction is suited to the needs of its district.

12. The provision to be made for technical education under this Act may include the providing of school laboratories, apparatus for teaching and experiment, museums and their contents, libraries, books, workrooms, schools or schoolrooms, or the improvement of existing provisions of any of these kinds, and the maintaining of the same in such manner as may be necessary to give effect to this Act.

13. (1) Save as otherwise provided by this Act the expressions "school board," "public elementary school," "managers," "parliamentary grant," and "Education Department," respectively, have the same meaning in this Act as in the Elementary Education Acts.

(2) The expression "local authority" means in any borough the council of that borough, and elsewhere the district council if district councils are established under any Act of the present session of Parliament, but if not then the urban sanitary authority or where there is no urban sanitary authority the county council.

The expression "local rate" means in a borough the school fund or borough fund or borough rate, and elsewhere the general district rate or other rate corresponding thereto.

14. This Act shall not apply to Scotland or Ireland.

SCIENTIFIC SERIALS.

Bulletins de la Société d'Anthropologie, tome onzième, série iii., fasc. 4 (Paris, 1888).—Conclusion of M. Variot's paper on the removal of marks of tattooing; and on an instrument for tattooing, by the same writer.—On the sacrum of a chimpanzee, by M. Chudzinski. In this case the sacrum was composed of seven vertebræ, the normal number in the Anthropoids being only five, or at most six.—A process for mounting histological specimens treated under paraffin, by M. Mahoudeau.—A description of the cranium and brain in two assassins, by MM. Fallot and Alezais. This communication gives a minute analysis of the convolutions and other parts of the hemispheres, while it supplies numerous and special measurements of the various parts of the skull together with the respective cerebral and cranial indices.—On the cranial alterations observable in rachitic conditions, by M. Regnault.—On the first temporal convolution in the right and left hemispheres, in the case of a person who was known to have suffered from deafness of the left ear, by M. Manouvrier.—A communication regarding the truth of the reports made by various travellers that cannibalism exists among the Fuegians, by M. Hyades. According to this writer there is absolutely no ground for this charge.—On a Peruvian bell, by M. Verneau.—On the antiquity of Egypt, and the evidences of its condition in prehistoric times, by M. Beauregard. In this very exhaustive article the author passes in review the material evidence remaining of the ages of cut and polished stone and of bronze. He believes that Egypt at the time of the Pharaohs exhibited the mixed condition of combining the use of flint implements with the simultaneous acquaintance with the means of extracting copper, and blending it with other metals, including tin, although no distinct hieroglyphic for the latter has been recognized in the older language of Egypt. It remains undetermined where and when first the ancient Egyptians obtained the tin which enters into the bronze fabricated in the valley of the Nile as far back as the seventeenth century before our era.—On the birth-rate in France, by M. Chervin. This paper contributes the most elaborate and detailed series of statistical tables, for the separate departments, of the births, marriages, and deaths registered, as well as of the numbers of children born in a definite number of households. The means obtained from these lists show that 8 per cent. of all the marriages in France are sterile, and that while 25 per cent. yield only one child, 100 families supply a mean of only 259 children. Many curious points of interest are suggested by this complex report, but it does not do much to explain the causes of the want of increase in the population of France, as compared with that of other countries.—On the hinged and cantoned cross in Cyprian decorative art, by M. Max Richter. The remains of ancient art in Cyprus strongly resemble those of Hissarlik, excepting that there is no trace of the *swastika*, or hinged cross on the decorated red jars of the Bronze Age, while its later appearance and disappearance in Cyprian art appears to coincide with the predominance and decline of Phœnician influence.—On the survival in Brittany of some of the usages and privileges of clanship, by M. Sébillot.—On a semi-pagan procession on St. John's day, in the Basses Alpes, by M. Arnaud. From time immemorial the peasants of Lauzet have proceeded after the benediction of the neighbouring lake to throw stones into its waters amid loud and angry cries of vengeance against the evil spirits who bring rain and hail storms. In this strange ceremony the local *curé* is constrained by popular will to take part.—On phallotomy among the Egyptians, by M. Letourneau.—On the centre of creation, and the first appearance of the human race, by M. Lombard. The writer supports Signor Saporta's view that vegetable forms, which now cover our continents, have spread slowly and continuously from north to south, recent species forcing back or obliterating those of more ancient origin. The laws which Signor Saporta endeavours to establish for the diffusion of vegetable forms, M. Lombard thinks may be extended to the animal kingdom, including man, whose cradle he would seek in circumpolar regions.—Report of sixth Conference on Transformism, under the presidency of M. Duval, by M. Bordier.—Report of fifth Broca-Conference, by M. Topinard, a member of the commission for awarding the prize instituted by Madame Broca in memory of her husband. The memoirs presented between 1885 and 1888 are not numerous, but great value attaches to two among these works, viz. the general ethnography of Tunis, by Dr. René Collignon, to whom the Broca Prize for 1888 has been unanimously awarded; and ethnological researches in regard to the human remains discovered at Spy, by M. Fraipont, who received a silver medal in recognition of the great merit of his work.—On the longevity of the Berber races, by M. Letourneau.—On a Palæolithic station on Mont Roty, and on a novel flint implement, by the Abbé Blanquet.—On an ancient cemetery at Biskra, Algeria, by M. de Mortillet.—On a sepulchral dolmen, discovered at Nanteuil-le-Houdouin (Oise), by MM. Collin and Lair.—A prehistoric station at Frileuse (Seine-et-Oise), by M. Vauvillé.

THE numbers of the *Botanical Gazette* (Crawfordsville, Indiana) for March and April contain a careful study of the histology of the leaves of *Taxodium* by Mr. Stanley Coulter, and a description of a number of new North American mosses, with illustrations, by Messrs. Renauld and Cardot. It is an evidence of the attention paid in the United States to microscopical technique, that this magazine frequently contains (as do both the numbers now before us) valuable hints as to the preparation of sections of tissues for the microscope, the use of staining reagents, or objects specially well calculated to demonstrate difficult points of structure.

IN the *Journal of Botany* for April and May, Messrs. Murray and Boodle complete their account of the genus *Avrainvillea* of Siphonocladaceæ.—Students of conifers will read with very great interest Dr. M. T. Masters's attempt to distinguish the North American pines, *Abies lasiocarpa*, *A. bifolia*, and *A. subalpina*, with their varieties or subspecies. The paper is illustrated by a series of excellent woodcuts.—Most of the other papers in these numbers are of special interest to students of British plants.

THE *Nuovo Giornale Botanico Italiano* for April, a large portion of which is devoted to a report of the proceedings of the Italian Botanical Society, contains several articles of general interest besides those devoted to the Phanerogamic and Cryptogamic botany of Italy.—Dr. H. Ross has an interesting article on the assimilating tissue and development of the periderm in the branches of plants with few or no leaves.—In pursuance of his careful examination of the Nymphæaceæ, Prof. G. Arcangeli now contributes a paper on the seeds of *Victoria regia*.—Signor U. Martelli adds a species to the few hitherto known of the genus *Riccia*—*R. atromarginata* from Sicily.—Signor C. Lumia gives the result of an examination of the composition of the gas found within the inflorescence of the common fig in an unripe condition, which contains more than 5 per cent. of carbon dioxide, showing that an active process of respiration must go on within the receptacle.—Signor G. Cuboni gives an account of experiments carried on with a view to check the plague of grasshoppers by infecting them with a parasitic fungus, *Entomophthora Grylli*, which had, however, only negative results.

Rendiconti del Reale Istituto Lombardo, April.—Palæontological notes on the Lower Lias of the Lombard fore-Alps, by Dr. C. F. Parona. These notes are communicated pending the publication of the author's exhaustive treatise on the fauna of Saltrio. They deal especially with the palæontological features of the Bergamo and Como districts in connection with the various faunas that flourished in the Lombard Sea during the Lower Lias epoch. The results of this summary survey agree generally with the conclusions arrived at by Prof. De Stefani in his comparative study of the various Lower Lias formations throughout Italy.—New measurement of the curvature of surfaces, by Prof. Felice Casorati. A new solution is presented of this problem, that of Gauss being shown to be defective and inadequate, although he laid the first solid foundation for the study of the subject in his classical work, "Disquisitiones generales circa superficies Curvas."—Prof. Giovanni Zoja contributes some historical notes on the cabinet of human anatomy in the University of Pavia, dealing more particularly with the period from 1815 to 1864 under the able administration of Bartolomeo Panizza.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 9.—"Zirconium and its Atomic Weight." By G. H. Bailey, D.Sc., Ph.D., the Owens College, Manchester.

Before proceeding with any final estimation, those salts of zirconium which were at all likely to be of service in the determination were exhaustively examined with special regard to their stability in presence of reagents and under the action of heat.

It was found that in consequence of their instability and tendency to form numerous oxychlorides, neither the chloride nor the oxychloride could be relied upon, and that the sulphate was the most suitable salt to work with. Even this salt when heated above 400° C. undergoes gradual decomposition with the production of basic salts, though it is quite stable up to this temperature A special method (applicable in a number of other atomic weights) was devised by which the normal salt could be obtained free from acid on the one hand, and from basic salt on the other. In order to have a sufficient check on the results, the carefully purified zirconia was further treated by four perfectly independent methods.

(*a*) The sulphate was prepared and its solution precipitated by means of hydrogen peroxide.

(*b*) The tetrachloride was prepared and its solution precipitated by ammonia.

(*c*) The sulphate was recrystallized several times from concentrated sulphuric acid and precipitated by ammonia.

(*d*) The oxychloride was prepared and recrystallized and precipitated by ammonia.

The average values obtained from the sulphate prepared from the specimens of zirconia so treated by determining the relation $Zr(SO_4)_2 : ZrO_2$, were :—

(*a*) 90·402
(*b*) 90·390
(*c*) 90·471
(*d*) 90·30
} mean 90·401.

In addition to the investigation of the salts which have been used in the estimation of the atomic weight, observations on the peroxides of zirconium discovered by Clève and the author are embodied, as well as an examination of the so-called metallic zirconium.

"Determining the Strength of Liquids by means of the Voltaic Balance." By Dr. G. Gore, F.R.S.

This method is based upon the circumstance that the greater the degree of concentration of a solution the larger is the amount of dilution required to reduce its voltaic energy to a given magnitude. The method of measuring the energy is described in Royal Society Proceedings, vol. xlv. p. 268.

In the present research a known volume of solution was taken, and the proportion of dissolved substance in it was found by ordinary chemical analysis. A second portion was taken, its specific gravity ascertained, and its degree of strength found by aid of the ordinary published tables of specific gravities. A third portion of known volume was then taken, its average amount of voltaic energy measured, and its degree of concentration ascertained by the amount of dilution required to reduce its voltaic energy to the same magnitude; the less dilute it was at starting the greater the amount of dilution required. The following are the results :—

By	HCl.	H_2SO_4.	HNO_3.	NaCl.	Na_2CO_3.	H_3N.
Chemical analysis	1·85	5·60	2·97	9·13	7·21	1·05
Specific gravity	1·70	5·44	2·80	8·74	7·63	1·03
Voltaic balance	1·65	5·70	2·90	8·71	7·57	1·06

A much less quantity of the substance is usually required by the voltaic balance method than by either of the other ones, and the operation is very quickly performed.

Physical Society, May 11.—Prof. Reinold, President, in the chair.—The following communications were read :—On an electrostatic field produced by varying magnetic induction, by Dr. O. J. Lodge, F.R.S. This paper describes a research made with the object of finding some connection between static electricity and magnetism. Several methods of attacking the problem, such as rotating or varying the strength of magnets in the neighbourhood of delicately suspended charged bodies, are indicated, and the one selected was based on an idea of Mr. A. P. Chattock, who conceived that a charged body in the vicinity of a closed magnetic circuit would be affected by varying the magnetic induction. From the theory of the effect it is shown that the magnitude of the quantity sought is exceedingly small, for the expression involves the inverse square of the velocity of light. The E.M.F. induced in any closed curve round the magnetic circuit or solenoid by varying the induction, I, is given by—

$$e = \frac{dI}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If an E.M.F., e, act on a charge, Q, at distance r from the axis of the solenoid, the work done in one revolution will be eQ, and

$$eQ = F \cdot 2\pi r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where F is the mechanical force. Now if the E.M.F. in (1) is the same as that in (2), the impulse given to the charged body by destroying the induction will be—

$$\phi = \int_0^\infty F dt = \frac{IQ}{2\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Since $I = \frac{4\pi n C A \mu}{l} = \mu C$ times a length, and $Q = sV = KV$ times a length,

$$\therefore \phi = \frac{K\mu CVA}{2\pi r} (\text{length})^2, \text{ and } K\mu = \frac{1}{\text{“}v\text{”}^2}; \quad \therefore \phi \propto \frac{1}{\text{“}v\text{”}^2}.$$

The magnetic circuit actually used was a wire Gramme ring of trapezoidal section, wound with copper over only a part of its periphery. The indicating apparatus was a suspended needle, consisting of two oppositely charged bodies carried on a small shellac arm, to which a mirror or pointer was attached, and was suspended vertically in the plane of the ring. Great difficulty was experienced from Foucault's currents when metallic films were used for the needle, and the magnetic properties and other semi-conductors tried further complicated the matter. Eventually, the charged bodies were made of paper, in the form of cylinders one-eighth of an inch diameter and three-eighths of an inch long. Considerable trouble was caused by the electrostatic action between the needle and exciting coils, and various methods of screening were tried and abandoned, and subsequently the wire was replaced by a single spiral of copper ribbon, the outer turn of which was put to earth. Observation was rendered difficult, owing to the wandering of the zero when the needle was charged, but this was minimized by suitably shaping the contour of the needle's surroundings. Heat also created considerable disturbance, and the convection currents were cut off by a series of concentric cylinders of tin plate. The method of observation was to charge the two insulated parts of the needle, and then reverse the magnetizing current in synchronism with the period of the needle, noting whether the amplitude of any residual swing could be increased or diminished according as the impulse assisted or opposed the motion. In this way, slight indications have been observed, and the effects reverse when the charges of the cylinders are reversed. In explaining the theory of the experiment, the author made use of a simple transformer, consisting of an ordinary hank of iron wire wound over with insulated copper and provided with several secondary coils; and by it he demonstrated that the primary current increases on closing the secondary, due, as was shown, to the decrease of self-induction of the primary caused thereby. Prof. Fitzgerald, in answer to a question from Dr. Lodge as to the influence of screens, said he had not fully considered the matter in this particular case, and, as the general effect of screens depended on the square of "v," the subject required careful treatment. As a means of checking the results obtained by Dr. Lodge, he suggested calculating the impulse, and seeing whether its magnitude approximately corresponds with that observed. Commenting on an idea for carrying out a similar experiment attributed to him in the paper, in which a charged gold leaf is placed between the poles of a magnet, Prof. Fitzgerald said he had been misunderstood, for he had conceived a disk parallel to the faces of the magnets, which, when excited, should cause the disk to turn in its own plane. Referring to the equations for mechanical force given in Maxwell, §619, he pointed out that the coefficient of e in the equation—

$$X = cv - bw - e\frac{d\psi}{dx} - m\frac{d\Omega}{dx}$$

ought to be P, where—

$$P = c\dot{y} - b\dot{z} - \frac{dF}{dt} - \frac{d\psi}{dx},$$

and considered it very important that the existence of the term $e\frac{dF}{dt}$ should be tested experimentally. Prof. S. P. Thompson mentioned some experiments on which he was engaged by which he hoped to show electric displacement in continuous dielectric circuits, such as a link of gutta-percha. Up to the present the experiments had not been successful, owing to his inability to place the two Gramme ring coils used into such relative positions as to give silence in the telephone connected with the coil used as secondary, when currents were sent through the primary. Prof. Ayrton suggested that Dr. Thompson's difficulty may arise from the fact that such rings do produce considerable external field, even when carefully wound.

Prof. Fitzgerald requested Dr. Thompson to investigate the effects of displacement-currents and of changing vector potential, and pointed out that in a single medium the former can produce no magnetic effect. As regards fields containing different media, he said the calculations would be complicated by the spurious charges on the separating surfaces. Dr. Lodge, in reply, said he had calculated the momentum to be expected in one arrangement of his experiment in which a suspended aluminium cylinder surrounds one limb of a rectangular magnetic circuit which formed the core of an induction coil; one end of the secondary was put to the core and the other to the cylinder, thus forming a condenser. The result came out about 10^{-6} dyne second, but he could not say whether such a small quantity was observable.—On the concentration of electric radiation by lenses, by Prof. O. J. Lodge, F.R.S., and Dr. James L. Howard. The authors' first attempts at concentration were made with mirrors on a comparatively small scale, and, owing to the difficulties experienced, it was considered advisable to try lenses. Two large cylindrical ones of plano-hyperbolic section were cast of mineral pitch in zinc moulds, the plane faces being nearly a metre square, the thickness at vertex 21 centimetres, and each lens weighed about 3 cwt. The eccentricity of the hyperbola was made 1·7, to approximate to the index of refraction of the substance. The lenses were mounted about 6 feet apart, with their plane faces parallel, and towards each other on a table in the College corridor, and an oscillator was placed about the principal focal line of one of them at a distance of 51 centimetres from the vertex. The field was explored by a linear receiver made out of two pieces of copper wire mounted in line on a piece of wood, and the air-gap between their inner ends was adjustable by a screw. When the oscillator worked satisfactorily, the receiver would respond at about 120 centimetres, and with the lenses the distance was 450. The receiver responded anywhere between the lenses, and within the wedge between the second lens and its focal line, the boundaries being clearly defined, but no special concentration was noticed about the focus. Interference experiments were carried out by placing a sheet of metal against the flat face of the second lens, and determining the positions of minimum intensity between the lenses. The distance between these points was 50·5 centimetres, corresponding with a wave-length of 101 centimetres, whereas the calculated wave-length of the oscillator was 100 centimetres. Prof. Fitzgerald congratulated the authors on their success, and also pointed out that although large oscillators give good results at distances within a few wave-lengths, yet at greater distances small ones were decidedly superior, owing to the energy of radiation varying as the fourth power of the rapidity. He had recently made experiments on electric radiations analogous to Newton's rings, and had successfully observed the central dark spot and the first dark band. Referring to Dr. Lodge's experiments, he inquired whether any traces of diffraction were observed near the boundary of the bundle of rays between the lenses. Speaking of polarization experiments, Prof. Fitzgerald said waves reflected from films of water exhibited no polarization, whereas those reflected from non-conductors were completely polarized. In reply, Dr. Lodge said no diffraction-effects had been observed, but in the interference-experiments to determine wave-length, the positions of minimum effect were very decided.—The President, in proposing that the thanks of the meeting be given to the authors of the papers, congratulated the Society on the presence of both Dr. Lodge and Prof. Fitzgerald on the present occasion, when subjects with which they were so well acquainted were brought before the meeting.

Chemical Society, May 2.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—Thiophosphoryl fluoride, by Prof. T. E. Thorpe, F.R.S., and Mr. W. J. Rodger. Thiophosphoryl fluoride, PSF_3, may be prepared by the action of arsenic trifluoride on thiophosphoryl chloride, or by heating a mixture of bismuth trifluoride or lead fluoride with phosphorus pentasulphide in a leaden vessel at a temperature not exceeding 250°. It is a transparent colourless gas, which under a pressure of ten to eleven atmospheres at ordinary temperatures condenses to a colourless, mobile liquid. It is slowly decomposed by water into sulphuretted hydrogen, phosphoric acid, and hydrogen fluoride, but does not attack mercury, and can be stored in a glass gas-holder. In air it is spontaneously inflammable, burning with a greyish-green flame forming phosphorus pentafluoride, phosphorus pentoxide, and sulphur dioxide, and it spontaneously explodes with oxygen. When heated, or subjected to electric sparks, it is decomposed with separation of sulphur and phosphorus, and formation of phosphorus trifluoride, and eventually phosphorus pentafluoride, whilst if the heating be effected in a glass tube at a sufficiently high temperature the gas is ultimately converted into silicon tetrafluoride. Thiophosphoryl fluoride combines with ammonia forming a solid product $P(NH_2)_2SF$, and when shaken with a moderately strong solution of alkali it is absorbed with the formation of a thiophosphate and a fluoride.—The boiling-point of sodium and potassium, by Mr. E. P. Perman. Sodium and potassium were boiled in a hollow iron ball which was heated by means of a blowpipe; the temperature was found in each case by means of an air thermometer consisting of a glass bulb with a capillary stem which was lowered into the vapour, sealed and broken open under water. The mean result for sodium was 742°, and for potassium 667°.—Note on the heat of neutralization of sulphuric acid, by Mr. S. U. Pickering. Calculating the value of the heat of neutralization of sulphuric acid in infinity of water from the results of a series of experiments on the dilution of the acid, the author finds that it becomes reduced to 28,197 cal., a value within experimental error, the same as that of two molecules of hydrogen chloride.—α-ω-diacetylpentane and α ω-dibenzoylpentane, by Dr. F. S. Kipping and Prof. W. H. Perkin.—Acetopropyl- and acetobutyl-alcohol, by Dr. H. G. Colman and Prof. W. H. Perkin.

Royal Meteorological Society, May 15.—Dr. W. Marcet, F.R.S., President, in the chair.—The following papers were read:—Account of some experiments made to investigate the connection between the pressure and velocity of the wind, by Mr. W. H. Dines. These experiments were made for the purpose of determining the relation between the velocity of the wind and the pressure it exerts upon obstacles of various kinds exposed to it. The pressure-plates were placed at the end of the long arm of a whirling machine which was rotated by steam power. The author gives the results of experiments with about twenty-five different kinds of pressure-plates. The pressure upon a plane area of fairly compact form is about 1½ pounds per square foot, at a velocity of twenty-one miles per hour; or, in other words, a pressure of 1 pound per square foot is caused by a wind of a little more than seventeen miles per hour. The pressure upon the same area is increased by increasing the perimeter. The pressure upon a ½-foot plate is proportionally less than that upon a plate either half or double its size. The pressure upon any surface is but slightly altered by a cone or rim projecting at the back, a cone seeming to cause a slight increase, but a rim having apparently no effect.—On an improved method of preparing ozone paper, and other forms of the test, with starch and potassium iodide, by Dr. C. H. Blackley. Some years ago the author made some experiments with the ordinary ozone test-papers, but found that the papers did not always give the same result when two or more were exposed under precisely the same conditions. He subsequently tried what reaction would take place between unboiled starch and potassium iodide when exposed to the influence of ozone; but the difficulty of getting this spread evenly upon paper by hand so as to insure a perfectly even tint after being acted upon by ozone led him to devise a new method of accomplishing this. Briefly described, it may be said to be a method by which the starch is deposited on the surface of the paper by precipitation, and for delicacy and precision in regulating the quantity on any given surface leaves very little to be desired.—Notes on the climate of Akassa, Niger Territory, by Mr. F. Russell. This paper gives the results of observations made from February 1887 to October 1888 at Akassa, which is the seaport and principal depot of the Royal Niger Company, and is situated at the mouth of the River Nun in the Niger Delta.—Wind storm at Sydney, New South Wales, on January 27, 1889, by Mr. H. C. Russell, F.R.S.

Geological Society, May 8.—W. T. Blanford, F.R.S., President, in the chair.—The following communications were read:—The rocks of Alderney and the Casquets, by the Rev. Edwin Hill. The author in this paper described Alderney, Burhou, with its surrounding reefs, and the remoter cluster of the Casquets, all included within an area about ten miles long. The reading of the paper was followed by a discussion, in which the President, Prof. Bonney, Dr. Woodward, Dr. Hicks, and others took part.—On the Ashprington volcanic series of South Devon, by the late Arthur Champernowne. Communicated by Dr. A. Geikie, F.R.S. The author described the general characters of the volcanic rocks that occupy a considerable area of the country around Ashprington, near Totnes. They comprise tuffs and lavas, the latter being sometimes amygdaloidal and sometimes flaggy and aphanitic. The aphanitic rocks approach in character the porphyritic "schalsteins" of Nassau. Some of the rocks are much altered; the felspars are blurred, as if changing to saussurite, like the felspars in the Lizard gabbros. In other cases greenish aphanitic rocks have, by the decomposition of magnetite or ilmenite, become raddled and earthy in appearance, so as to resemble tuffs. The beds are clearly intercalated in the Devonian group of rocks, and the term Ashprington Series is applied to them by the author. Alrhough this series probably contains some detrital beds, there are no true grits in it. Stratigraphically the series appears to come between the Great Devon Limestone and the Cockington Beds, the evidence being discussed by the author, however, not so fully as he had intended, as the paper was not completed. The President said that the thanks of the Society were especially due to Dr. Geikie for having rescued this paper from oblivion. Dr. Geikie, after alluding to the melancholy interest attaching to the paper, said that he had himself urged the author to formulate his ideas upon the structure of the country. The present communication, however, was all that was found among his papers in a condition for publication. But it is imperfect, and no materials remained from which it could be completed; still it was too valuable a piece of work to leave unpublished. There were two principal points in this last work of Mr. Champernowne: (1) the non-intrusive character of the beds in question; (2) their geological horizon, regarding which, though, owing to the faulted nature of the country, it is rather obscure, Mr. Champernowne's surmises may turn out to be correct. There was no allusion in the paper to the compression and shearing the rocks had undergone, to which he (Dr. Geikie) attributed much of the schistose structure both of the sedimentary and igneous rocks of the region. The flaky beds of which the author speaks can be traced into the more massive rocks. The flattening out of the amygdaloids was a striking proof of this mechanical deformation. Some remarks on the paper were also offered by Mr. Rutley, Dr. Hatch, Mr. Worth, and Mr. W. W. Beaumont.

Zoological Society, May 7.—Prof. Flower, F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of April 1889, and called attention to a young male Sinaitic Ibex (*Capra sinaitica*), from Mount Sinai, presented by Sir James Anderson; and to a young male of the Lesser Koodoo (*Strepsiceros imberbis*), from East Africa, presented by George S. Mackenzie.—Mr. Sclater exhibited and made remarks on a living specimen of an albino variety of the Cape Mole (*Georychus capensis*), lately presented to the Menagerie by the Rev. George H. R. Fisk, C.M.Z.S.—The Secretary read a letter addressed to him by Dr. E. C. Stirling, of Adelaide, containing a copy of his description of a new Australian burrowing Mammal, lately published in the Transactions of the Royal Society of South Australia, and promising to send to the Zoological Society a more complete account of the same animal.—Mr. Seebohm exhibited and made remarks on the skin of a male example of *Phasianus chrysomelas*, which had been transmitted in a frozen state from the Trans-Caspian Provinces of Russia.—A communication was read from Colonel C. Swinhoe, containing descriptions of seventy-five new species of Indian Lepidoptera, chiefly Heterocera.—A communication was read from Rev. O. P. Cambridge, containing the description of a new Tree Trap-door Spider from Brazil, proposed to be called *Dendricon rostratrum*.—Mr. F. E. Beddard read some notes on the anatomy of an American Tapir (*Tapirus terrestris*), based on a specimen lately living in the Society's Collection.—A communication was read from Prof. Bardeleben, of Jena, on the præpollex and præhallux of the Mammalian skeleton. The author recorded the presence of a two-segmented nail-clad præpollex in *Pedetes*, and that of a two-segmented pisiform (post-minimus) in *Bathyergus*. He also stated that he had discovered vestiges of the præhallux and præpollex in certain Reptilia. He then passed to the consideration of the Mesozoic *Theriodesmus* of Seeley, and denied the existence of the *scapho-lunare* of that author, while he produced good reason for believing the same observer's second *centrale* to consist of two elements, and his præaxial *centrale* to be the basal element of a præhallux.—Mr. Oldfield Thomas read the description of a new genus and species of Muridæ from Queensland, allied to *Hydromys*, which he proposed to call *Xeromys myoides*.

Mathematical Society, May 9.—J. J. Walker, F.R.S., President, in the chair.—The following communications were made:—On the solution in integers of equations of the form $x^3 + y^3 + Az^3 = 0$, by S. Roberts, F.R.S.—On the concomitants of K-ary quantics, by W. J. C. Sharp.—Note on the G function in an elliptic transformation annihilator, by J. Griffiths.—On the complete elliptic integrals K, E, G, I, by Dr. J. Kleiber, *Privat-docent* of the University of St. Petersburg.—On the motion of an elastic solid strained by extraneous forces, by Signor Betti ("by *symmetrical algebraic analysis*, the author obtains an expression, in terms of the rotations of the element, for the unbalanced couples acting on each element of a solid when strained by given forces; and he points out that the result is in accordance with a form of the elastic equations given by Sir W. Thomson").—On cyclotomic functions, § iii. the cyclotomics belonging to the f-nomial periods of the pth roots of unity, where p is a prime number, by Prof. Lloyd Tanner.

EDINBURGH.

Royal Society, April 1.—Sir W. Thomson, President, in the chair.—Prof. Tait communicated some of the results obtained from a series of experiments on impact of various bodies.—Sir W. Thomson exhibited and described new forms of magnetostatic current- and volt-meters, and an electro-static voltmeter with a multiple voltaic pile to facilitate graduation.—Mr. A. Crichton Mitchell gave an account of the properties of manganese steel.—Dr. W. Peddie described an improved method of measuring small rotations of the plane of polarization by ordinary apparatus.—Prof. Tait read a paper on the relations between line-, surface-, and volume-integrals. He showed that the well-known relation between line- and surface-integrals can be deduced directly from a particular case of the equally well-known relation between surface- and volume-integrals.

April 15.—Prof. Sir Douglas Maclagan, Vice-President, in the chair.—The Keith Prize for 1885–87 was awarded to Mr. J. Y. Buchanan for a series of communications on subjects connected with ocean circulation, compressibility of glass, &c.—The Makdougall-Brisbane Prize for 1884–86 was awarded to Dr. John Murray for his papers on the drainage areas of continents, and ocean deposits, the rainfall of the globe, and discharge of rivers, the height of the land and depth of the ocean, and the distribution of temperature in the Scottish lochs as affected by the wind.—The Makdougall-Brisbane Prize for 1886–88 was awarded to Dr. Archibald Geikie for numerous communications, especially that on the history of volcanic action during the Tertiary period in the British Isles.—Prof. Swan read an obituary notice of the late Mr. R. M. Smith.—Dr. E. Sang read a paper on the resistance of the air to the motion of an oscillating body with special reference to its effect on time-keepers.—Mr. A. Johnstone communicated a paper on a new and easy method for the rapid and sure detection of mercury.

PARIS.

Academy of Sciences, May 13.—M. Des Cloizeaux, President, in the chair.—The thionic series, by M. Berthelot. In this paper the author studies the action of the acids on the thiosulphates, which throws quite a new light on the constitution of the salts of the thionic series, by determining the limits of the heat of neutralization of thiosulphuric acid. The liberated sulphur reacts with the thiosulphuric acid before it decomposes, forming complex thionic acids.—On mesocamphoric acid, by M. C. Friedel.—The author has prepared this substance by a process different from that of Wreden, by whom it was first described, and some of whose statements are here rectified. Instead of being an inactive, non-decomposable acid, it is found to be decomposable by simple crystallization.—On the photographic spectrum of the great nebula of Orion, by Dr. W. Huggins. In 1882 the author obtained a photograph of the spectrum of this nebula, revealing a new luminous ray with wave-length about λ3730. Two recent photographs taken in 1888 and 1889 enable him to determine more accurately this wave-length, as well as to describe a certain number of other luminous rays which occur in the ultra-violet region of the spectrum of the same nebula. These photographs are figured in a drawing which accompanies the present note. The wave-length of the bright ray discovered in 1882 is here determined at λ3724. Dr. Huggins considers it probable that nebulæ yielding a spectrum of luminous rays, with a very faint continuous spectrum, which is probably formed in part by luminous rays in close proximity, are at or near the beginning of the cycle of their celestial evolution, while those resembling the large nebula in Andromeda have already reached a more advanced phase of their development. The photograph of this nebula taken by Mr. Roberts reveals a planetary system, in which some planets are already formed, and their central mass condensed.—On the surgical treatment of the foot in cases of suppurated osteo-arthritis, by M. Ollier. Hitherto amputation has generally been considered the only remedy; but the author's experiments show that, by removal of the ankle with abrasion or resection of the limiting articulations, the foot may be preserved almost in its normal state and with little detriment to its locomotive functions.—On the linear expansion of solid bodies at high temperatures, by M. Pionchon. These researches show that by means of the simple process here described M. Fizeau's well-known experiments may be repeated with the greatest ease. M. Pionchon now proposes to apply the process to the study of the linear expansion of amorphous and crystallized solid bodies at high temperatures.—On the direct measurement of the retardation produced by the reflection of luminous waves, by M. A. Potier. These experiments, which are applicable to a large number of substances, constitute a method by means of which the retardation may be directly measured, which is caused by the reflection of the luminous waves on their surface.—On the influence of terrestrial magnetism on atmospheric polarization, by M. Henri Becquerel. In a previous memoir (*Annales de Chimie et de Physique*, xix., 1880) the author showed that in a cloudless sky the plane of polarization is not generally coincident with the theoretic plane (plane of the sun), and further that the two should coincide when the latter is vertical, but that, in a region near the horizon and the magnetic meridian, the plane of polarization then deviates by a small angle in the direction corresponding to the rotation of the plane of polarization of a luminous ray traversing a column of air, subject to the magnetic influence of the earth. In the present paper he determines both the direction and the extent of the rotation, and also shows how this display of terrestrial magnetism is associated with some of the most interesting questions connected with the physics of the globe.—A study of the electric conductivity of saline solutions, as applied to chemical mechanics—the acid salts, by M. P. Chroustchoff. The author has applied M. Bouty's extremely sensitive electrometric method of measuring the electric conductivity of liquids to the study of several problems in chemical statics. In the present paper he tabulates the chief measurements of the electric conductivity of aqueous solutions containing one salt only. — Action of the atmosphere on manganese carbonate, by M. A. Gorgeu. In this paper the author discusses the question whether this action can give rise to any of the natural dioxides, as assumed by MM. Boussingault and Dieulafait.—Papers were contributed by M. L. Pigeon, on platinic chloride; by M. Aug. Lambert, on the action of borax on the polyhydric phenols and alcohols; and by M. H. Prouho, on the structure and metamorphosis of *Flustrella hispida*.—A copy of M. Seligmann-Lui's translation of Clerk Maxwell's classical treatise on "Electricity and Magnetism" was presented to the Academy by M. Sarrau.

BERLIN.

Physical Society, April 26.—Prof. Kundt, President, in the chair.—Prof. Kundt gave a short account of recent researches on electro-magnetic rotatory polarization, and developed the more general point of view from which they had been respectively undertaken. Since the time when Faraday discovered the fundamental phenomena and later physicists had accumulated a mass of material on which observations could be made, two facts had chiefly presented difficulties in connection with the established theory: of these one was the varying direction of rotation produced by different substances, some producing a positive rotation (in the direction of the Ampèrian current), others a negative rotation; the other fact was the absence of magnetic rotation in doubly-refractive crystals. Starting from some theoretical considerations, the speaker was led to surmise that rotation is not wanting in these crystals, but is only obscured by some opposing phenomenon, a view which has been fully confirmed by experiments carried out at his suggestion by Drs. Wedding, Wiener, and du Bois. When a piece of glass was made doubly refractive by pressure, its magnetic rotatory polarization diminished, becoming *nil* when the difference in path of the two rays was $\frac{1}{2}\lambda$; when the difference was $\frac{3}{4}\lambda$, then the rotation took place in the opposite direction. When the difference was λ, the rotation was again *nil*, and it varied thus in a wave-like manner, with increasingly small amplitudes until it ceased entirely. Prof. Kundt concluded from this that the power of electro-magnetic rotatory polarization is common to *all* substances, whether crystalline or isotropous. As regards the varying direction of rotation, his own experiments had shown that simple substances produce a positive rotation, and compound bodies a negative rotation; this last result may be explained by the fact that the Ampèrian currents inside compound bodies run in a direction different from that in the magnetic field. The proportionality of rotation to the strength of magnetization is also a property common to all substances; its relationship to refraction is being made the subject of further researches. Dr. Koenig (from Leipzig) pointed out many analogies which exist between the electrical rays discovered by Prof. Hertz and rays of light, more particularly the polarization of the electrical rays by means of the wire grating and the phenomena which may be observed in the immediate neighbourhood of the rays as they are advancing in straight lines, phenomena which are in exact accord with those described by Stokes in the case of light.

STOCKHOLM.

Royal Academy of Sciences, April 9.—Researches on the deviations of the plumb line in Sweden, by Prof. Rosén.—Résumé préliminaire d'une recherche expérimentale sur l'absorption de la chaleur rayonnante par les gaz atmosphériques, by Dr. Ångström.—Newly found specimens of *Anser brachyrhynchus*, Baill., in Sweden, by Dr. A. Stuxberg.—On a singular Tetrarhynchid larva, by Herr E. Lönnberg.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Eclectic Physical Geography: R. Hinman (Low).—A Treatise on the Principles of Chemistry, 2nd edition: M. M. P. Muir (Cambridge University Press).—Teutonic Mythology: V. Rydberg, translated by R. B. Anderson (Sonnenschein).—Die Entstehung der Arten durch Räumliche Sonderung: M. Wagner (Basel, B. Schwabe).—Examination of Water for Sanitary and Technical Purposes: H. Leffmann and W. Beam (Philadelphia, Blakiston).—Hourly Readings, 1886, Part 3. July to September (Eyre and Spottiswoode).—The Uses of Plants: G. S. Boulger (Roper and Drowley).—Journal of the Institution of Electrical Engineers, No. 79, vol. xviii. (Spon).—Quarterly Journal of the Geological Society, No. 178 (Longmans).—Ergebnisse der Meteorologischen Beobachtungen, Jahrg. x. (Hamburg).

CONTENTS.

THURSDAY, MAY 30, 1889.

INTERMEDIATE EDUCATION IN WALES.

IT does not often happen, in these days of slow Parliamentary progress, that two educational measures, having an important bearing on the industrial and the intellectual welfare of the country, are read a second time within a week of each other. In our last issue we gave some account of Sir Henry Roscoe's Bill for the provision of technical education, and expressed our strong hope that it would pass through the remaining stages this session. No less heartily do we wish success to Mr. Stuart Rendel's Bill for providing intermediate and technical education in Wales, which was read a second time on May 15, after a debate which practically resolved itself into a chorus of approbation. It is, indeed, high time that something should be done. Secondary education, both in England and Wales, stands sadly in need of organization, but the claims of the Principality (to which the present measure is confined) are far stronger than those of England, so far as the necessity of immediate action is concerned.

The main grounds on which the special treatment of Wales in this matter is based are to be found stated in the Report of Lord Aberdare's Committee on Intermediate and Higher Education in Wales, which was published in 1881. It is there pointed out that the aggregate income of the educational endowments of Wales and Monmouth amounted to little over £14,000, against a total of more than £600,000 for England (excluding Monmouth). Nearly a third of these scanty endowments were to be found in Monmouth. In the matter of these endowments Wales is no better off now than it was then. Since 1881, it is true, the educational resources of Wales have been increased by the grant of £12,000 a year to the three University Colleges of Aberystwith, Bangor, and Cardiff. But even including this sum, which is really intended for higher education, the educational income of Wales is not nearly so great in proportion to the population as in the case of England, and what there is is so unequally distributed as not to be available where the need is greatest.

The result is that in many counties of Wales intermediate education can hardly be said to exist. The Schools Inquiry Commission estimated that about sixteen boys in every thousand ought to be receiving intermediate or higher education. The following quotation from the Report to which we have referred will show the destitution which existed in Wales in 1881, and which unfortunately still exists to a great extent to-day :—"Taking the population of Wales and Monmouthshire to be about 1,570,000, and reducing the estimate in consideration of the exceptional conditions of Wales from sixteen to ten per 1000, intermediate school accommodation should be provided for 15,700 boys, and that number ought to be in attendance. In contrast to this, our returns show *accommodation* in the public schools for less than 3000, and that accommodation to a great extent unsatisfactory. They also show an *attendance* of less than 1600."

This estimate only applies to *boys*, and the state of the case as regards girls' education is still worse. Only from two to three hundred girls were in 1881 in schools under any kind of public supervision, and the Committee naturally found great difficulty in devising recommendations which should adequately meet a case where, as they say, "the unsatisfied requirements are so great and the available resources apparently so meagre." Probably, on the whole, intermediate school accommodation ought to be provided for at least fifteen children per 1000 of the population, making a total of 23,500 school places. Less than a fifth of this number were provided in 1881 in schools under any kind of public supervision or control.

So much for the state of the case. Lord Aberdare's Committee reported in favour of aid being given to Welsh intermediate education both from rates and Imperial grants. Progress, however, in these matters is so slow in England that nothing has hitherto been done to carry out these recommendations except the drafting of a Bill by Mr. Gladstone's Government in 1885. This measure was essentially the same as Mr. Stuart Rendel's Bill which is now before the public.

The Bill embodies most of the recommendations of Lord Aberdare's Committee. It proposes to create a Board of Education for Wales, consisting of representatives of County Councils. To this Board schemes are to be submitted by the Council of each county, to meet the educational needs of that district. The plans may include the establishment of new schools, the reorganization of endowments, and the provision of scholarships. The Board may approve or alter the plans, and the funds required to carry them into effect are to be raised by a rate not exceeding one halfpenny in the pound—a sum, by the way, which will produce about £14,000 a year for the whole of Wales. This sum may be met by a Parliamentary grant not greater than the amount raised from the rates, subject to favourable reports upon inspection. Powers are given to reorganize and utilize existing endowments, and there may no doubt be some difference of opinion as to the extent and nature of the powers in relation to this matter which the Bill proposes to give to the new Board of Education.

There are a few criticisms which may be made on points of detail. The Board of Education ought undoubtedly to include not only representatives of the County Councils, but a certain number of educational experts. The County Councils should likewise be empowered to co-opt men of special knowledge to help in the preparation of their schemes. But on such points the representatives of Wales—a country where, as all who know it well will admit, there is a sincere zeal for educational progress—will not be likely to offer unreasonable opposition.

On the whole, the Bill is a most important step in advance, leading, as we may hope, ultimately to the organization and supervision of secondary schools throughout the Kingdom. All interested in the advance of scientific and technical teaching know how higher institutions are crippled by want of better teaching in secondary schools. The teachers in technical schools and higher colleges in England constantly complain of the want of preparation of those who come to their institutions from private schools. In Wales much of the work which the University Colleges are now compelled to do ought to be done in intermediate schools. We hail the fact that the Bill was read a second time as a sign that the public are waking up to the very great importance of this side of the educational problem.

FLORA ORIENTALIS.

Flora Orientalis, sive Enumeratio Plantarum in Oriente a Græcia et Ægypto ad Indiæ Fines hucusque Observatarum. Auctore Edmond Boissier. Supplementum, editore R. Buser. (Genevæ et Basileæ apud H. Georg, Bibliopolam, 1888.)

A BRIEF notice of the eminent author of the monumental work which the present volume brings to a close appeared in NATURE (vol. xxxii. p. 540), a day or two after his decease, and it is there mentioned that he had for some time been engaged on a supplement to his "Flora Orientalis," the body of which was completed in 1881. That supplement is now fortunately in the hands of botanists, and an opportunity is offered for a more comprehensive notice of the author and his work, as a whole, than has hitherto been published in this country. Apart from the value of the work to the systematist and phytogeographer, it possesses an interest for a wide circle, inasmuch as it deals with the vegetation of those countries of the greatest historical attractions. As the title indicates, the eastern limit of the area of the "Flora Orientalis" is India, and now there are other works actually in progress, which, although they will not by any means exhaust the flora of the rest of Asia, will add vastly to what is known. Sir Joseph Hooker's "Flora of British India" has reached the sixth volume, and the indefatigable author is now engaged on the Orchideæ (the largest order in the British Indian flora, represented by upwards of 1000 species); and we may reasonably hope, now that he is free from official duties, that he will finish it in the course of four or five years. But the energy and perseverance required to get through such an amount of descriptive botany as that accomplished by such men as Bentham, Boissier, and Hooker, can be estimated by few except those similarly engaged.

Regel and Maximowicz's elaboration of the collections of Russian travellers in Central and Eastern Asia, Franchet's "Plantæ Davidianæ" and "Plantæ Yunnanenses," and Forbes and Hemsley's "Index Floræ Sinensis," are jointly bringing together the materials for a flora of Central Asia and China, so that it will soon be possible to survey and analyze the composition of the vegetation in its various aspects from the Atlantic across Europe and Asia to the Pacific.

The "Flora Orientalis" consists of five octavo volumes, with an aggregate of 5387 pages, independently of the present supplement of 499 pages, making a total of 5886 pages; and, on the authority of Dr. H. Christ, the author of a notice of the life and works of Boissier appended to the supplement, the number of species described amounts to 11,876! To these descriptions are added the localities of the plants within the limits of the "Flora," and the geographical area of each species. In giving the former, the author takes the countries in the following order: Greece, Macedonia and Thrace, Asia Minor and Armenia, Egypt and Arabia, Palestine, Syria, and Mesopotamia, Crimea and Caucasus, Persia, Turkestan, Afghanistan and Baluchistan.

Before proceeding to a further examination of the nature and quality of Boissier's "Flora Orientalis," I will extract some particulars of his life from Dr. Christ's memoir, more especially such as relate to his botanical career.

Pierre Edmond Boissier, a descendant of a Huguenot family, was born at Geneva in 1810, and early developed a love for botanical pursuits. This inclination was stimulated and cultivated by the eminent Augustine Pyramus De Candolle, whose admirable teaching resulted in Boissier's life-long devotion to botanical research. Boissier was a man of great mental attainments, of a most amiable disposition, and at the same time of noble stature and fine physique.

Botanizing in the field, which is undoubtedly the best of all training, was his great delight, and his home excursions subsequently extended into distant travels. He was a good walker and a good mountaineer, and retained his great physical power until quite late in life. On his first visit to the Maritime Alps in 1832, he walked the whole distance, some forty miles, from Nice to Tenda in a single journey, and as lately as 1871 he accomplished in one day on foot the longer and much more difficult journey from La Madone delle Finestre to Tenda. The distance is estimated at about forty-five miles, and entails an ascent from 1900 to 2336 metres, then a descent to 1500 metres, upwards again to 2600, and finally down to 750 metres. And this exertion was undertaken to rediscover the rare and singular *Saxifraga florulenta*, originally discovered by an English tourist. This, Boissier's fourth excursion for this object, proved successful.

After finishing his studies at Geneva, Boissier went to Paris, where he met with our countryman Philip Barker Webb, who had botanized extensively in Spain, chiefly in the Kingdom of Granada, though he had published almost nothing thereon. It is supposed that Webb influenced Boissier in his determination to make Spain the field of his next botanical work, and it is certain that he gave him the whole of the materials he had collected, having himself made the Canary Islands the scene of his future labours. Boissier went on his first voyage to Spain in 1836, and continued his investigations for several years, aided more or less by several persons, and greatly by his friend Reuter. Following several preliminary contributions to the botany of Spain, the first part of Boissier's "Voyage botanique dans le midi de l'Espagne" appeared in 1839; and this admirable publication was completed in 1845. It is a botanical work of the first rank, and an enduring monument of the industry and munificence of the author. It consists of two quarto volumes containing a most interesting narrative of his travels; an essay on the geographical distribution of the plants of the region under consideration; descriptions of all the plants, and last, though by no means least, upwards of 200 beautifully drawn, hand-coloured plates by Heyland, one of the most accomplished botanical artists of his time.

Previous to the appearance of this work, the flora of no country of Europe was so little known as that of Spain. The enumeration numbers nearly 2000 species, about one-eighth of which were previously unknown. Since its appearance the flora of the whole of Spain has been elaborated by Willkomm and Lange—by foreigners again, and not by Spaniards! As a noteworthy exception to the botanical lethargy of the Spaniards, the learned and valuable works on the botany and botanists of the Iberian Peninsula by Don Miguel Colmeiro deserve special mention in this connection. Boissier himself, although he soon afterwards became engaged upon a work of much greater magnitude, never lost interest in the flora of Spain, and he revisited the country many times. Even before the completion of his "Voyage en Espagne," he commenced travelling and collecting in South-Eastern Europe, subsequently visiting Egypt, Palestine, and Arabia, and other countries; the results of these journeys culminating in his *magnum opus*, the "Flora Orientalis." Preliminary to this work he published a vast number of new species in fascicles, from time to time, between 1842 and 1859, under the title of "Diagnoses Plantarum Orientalium Novarum." Another important contribution to systematic botany was his "Icones Euphorbiarum," a large quarto, containing figures and descriptive letter-press of 120 species of Euphorbia. This was published in 1866, and in the same year the author furnished descriptions of the seven hundred species of this genus for De Candolle's "Prodromus."

Apart from its size, the "Flora Orientalis" is incontestably one of the most masterly pieces of descriptive botany ever executed, and although many botanists will not agree with the illustrious author in his limitation of species, all will recognize the excellence of the descriptions, and admit that by their aid a botanist can actually "determine" his plants. On this point I can speak from successful personal experience. The analytical keys to the species of some of the larger genera are admirably constructed, and display a marvellously acute knowledge, as well as great power of discrimination Take such genera as *Campanula* (125 species), *Cousinia* (136 species), Centaurea (183 species), Silene (204 species), and Astragalus (757 species), as examples of the work, and it will be admitted that few approach it in quality.

With regard to his conception of species, Boissier rejected the Darwinian theory altogether, believing that species were not arbitrary congeries of individuals, but direct creations of God at different periods. And although he by no means carried subdivision to the absurd extent that some modern botanists have done, yet he went much farther in this direction than most authors who have dealt with the vegetation of so wide an area as that of the "Flora Orientalis."

The supplement, issued towards the end of last year, is brought down to a very recent date, and contains all Dr. Aitchison's additions to the Afghan flora, except those in his last paper, of course, which was not published till the spring of last year. It also includes an index to all the collectors' numbers cited throughout the work, which will be very useful to persons possessing these numbered collections. A portrait of the author late in life forms the frontispiece to this volume, and there are several views of the new building erected on the bank of the lake, not far from Geneva, to contain the fine herbarium amassed by Boissier.

Thus Geneva now possesses the remarkably rich herbaria of De Candolle, De Lessert, and Boissier.

W. BOTTING HEMSLEY.

A TREATISE ON MANURES.

A Treatise on Manures. By A. B. Griffiths, Ph.D. (London: Whittaker and Co., 1889.)

IN this substantial little volume of nearly 400 pages the author treats of natural and artificial fertilizers, with a decided leaning towards the latter. The work is intended to be useful to manure manufacturers as well as to farmers and students of agriculture, and must be regarded as a useful addition to our information. The subject is introduced by two chapters upon the soil and the plant, after which all the leading and the suggested fertilizers are reviewed, and analyses are furnished. It is convenient to have at hand a book written up to date in which the newest sources of phosphatic materials, guanos and alkalies, are brought under notice. The chief interest of Dr. Griffiths's book centres in his chapter upon the use of iron sulphate as a manure. It is well known that Dr. Griffiths first pointed out that the iron sulphate, used in small quantities of about half a hundredweight per acre, exerts a beneficial effect on many crops; and this fact is distinctly brought before the reader in the book before us. The value of sulphate of iron lies in the fact that many soils do not contain a sufficiency of iron in a form to be readily taken up by plants, and Dr. Griffiths considers that when added to such soils it tends to increase the amount of chlorophyll in the leaf, and that this is followed by increased vigour in the elaboration of starch, woody fibre, fats, carbohydrates, and albuminoids. The amounts of increase of crop in the cases cited are remarkable, and the greater percentage of iron in the ashes of plants top-dressed with this substance is decided. It would be unjust to Dr. Griffiths to detract from the value of this observation, which, as he tells us, has been the cause of hundreds of letters on the subject from all parts of the world. The results are indeed open to the criticism that they are almost too satisfactory, for an increase of 19,313 pounds per acre of mangel owing to the use of half a hundredweight of sulphate of iron seems almost too good to be true. Nine tons of mangel are worth something like £6 sterling to the farmer as food for stock, a sum which would effectually turn an unprofitable into a profitable crop. The season is still young, and it would be well if agriculturists would put Dr. Griffiths's results to the test of a simple experiment during the coming summer, upon root crops.

Dr. Griffiths is no great partisan of farmyard manure, and he is scarcely fair in his argument when he touches upon this important subject. We cannot agree with him that farmyard manure is "far from being a perfect manure," or that "the farmer who uses nothing but farmyard manure exhausts his land," or that "farmyard manure does not return to the soil all the nitrogen which was originally extracted from it by growing crops." In pursuing this argument he asks, "Whence comes the fertilizing matter contained in the dung of animals? An ox or a sheep cannot create nitrogen, phosphorus, or potash. All of these substances, which are to be found in its liquid and solid excrements, have been derived from its food. That food has been grown upon the farm."

This is doubtless true if the farm actually does produce all the food of the animals it supports; but every farmer knows that this is not the case. The believers in the value of farmyard manure know perfectly well that the sale of lambs, of young stock, and of dairy produce, as well as of beef, mutton, and wool, exhausts land; but, in order to counteract this tendency, they invariably (we speak of good farmers) purchase oil-cake, hay, and corn in large quantities, sometimes to the extent of from £1 to £2 per acre over the entire farm, and it is this fact which is ignored by Dr. Griffiths. As to whether farmyard manure is a cheap manure or the reverse depends greatly upon the skill of the farmer, but we may be sure that when it is produced by well-bred animals, of high value, or when purchases of stock are made judiciously, farmyard manure may be properly regarded as a by-product.

It is questionable teaching on the part of an agricultural chemist to run counter to the experience of practical men, and we fear that Dr. Griffiths will not carry his agricultural readers with him in his opinions regarding the exhausting nature and expensive character of farmyard dung. Warming with his subject, Dr. Griffiths asks, "Why will the farmer still go sinking in the Slough of Despond, while faithful and willing hands are continually being stretched out in every direction to help him? Let him take a word of warning. Be up and doing, and—whatever you (*sic*) do—be up to the times. Do not let German, French, Belgian, or American agriculturists, simply by dint of superior scientific knowledge and methods, outstrip you in that great competition which is now going on amongst the nations of the world." As in the previous quotation given, we see once more the learned Doctor arguing upon wrong premises. In what respects do German, French, Belgian, or American agriculturists outstrip the English farmer? The average yields of corn and the average results of stock-feeding obtained by British farmers are far superior to those obtained by German, French, and American farmers. The manner in which our farmers have stood the shock of rapidly falling grain prices is extraordinary. Farming has not ceased to be a profitable occupation, but times have recently been very difficult, partly on account of the fall in the value of corn, and partly because the seasons have been remarkably unfavourable for the last fifteen years.

Dr. Griffiths proceeds to point out that in 1884 Germany boasted 158 colleges and schools of agriculture, attended by 17,844 students, and contrasts this fact with the very few colleges and the 240 students of agriculture in England. "If, says he, "Old England is to hold her own, we must have these necessities. It may be said, Is not England already taxed enough? where is the money to come from to support the colleges, schools, and experimental farms? We all admit that England is the *richest* country in the world. Very well, then, if *poor* Germany can support at least 158 agricultural colleges, and give instruction to 17,844 students, surely England need not grumble or be so mean." Does not Dr. Griffiths know that the farmers, as a rule, in Germany and France, do not care about the agricultural colleges? that there is the greatest possible difficulty in inducing them to send their sons to them? that it is only by offering exemption from the galling military service exacted from all men in those countries, and by conferring upon students the rank necessary for serving as officers in the army, that the colleges and schools are filled at all? Does he not know that the colleges and schools are chiefly useful as a means of training the great army of professors and teachers in those countries? Does he not know that a certificate of proficiency gained at a college is, in those countries, absolutely necessary before a man can give evidence in a court of justice on an agricultural question? Does he wish to introduce artificial restrictions such as this into England, and to substitute a patriarchal system for that free enterprise which is the true reason of the wealth and the excellence of England?

A very short time ago £5000 was put aside by the Government for grants on account of agricultural education. No sooner was this offered than a struggle ensued for participation in this small sum. Share lists have been opened, in which one source of profit put before the investing public is a share of this same £5000 as a means of increasing the dividends of the promoters! It is more than likely that this same £5000 will do more harm than good, by encouraging bogus schemes and paralyzing the natural enterprise which is the life-blood of English supremacy.

Dr. Griffiths has issued his book, and farmers are free to read, mark, learn, and inwardly digest it. The agricultural press is open, and there is that great body of good practical farmers who are more fully alive to the situation than Dr. Griffiths imagines, who, if not "scientific" in their instincts, are shrewd men of business, and the possessors of a knowledge of rural matters which comes not from books, but through contact and experience.

Dr. Griffiths is a disciple of Ville, and the main object of his work is to substitute a system of artificial fertilizers for manuring through live stock. Farmyard manure, he says, is imperfect, full of seeds of weeds and germs of disease; it is expensive to produce and to apply; it exhausts the land; it is inferior to artificial manures; and its good properties, such as they are, are not easily recoverable. Such is Dr. Griffiths's indictment, which is calculated to make farmers rub their eyes, and, having made sure they had read aright, lay the book down. If experience is of any value at all in regulating practice, it teaches us that in our climate, and with our natural and acquired advantages in races of cattle, the strength of our position is our live stock; that the fertility of the soil is not only kept up but rapidly and durably increased by the importation of purchased foods; and that it is better for the farmer to pay a "cake" bill than a manure bill.

OUR BOOK SHELF.

Elementary and Synthetic Geometry of the Point, Line, and Circle in the Plane. By N. F. Dupuis, M.A. (London: Macmillan, 1889.)

THIS is a work which we have read with considerable interest. As the author states, "it is not an edition of Euclid's 'Elements,' in fact it has little relation to that celebrated ancient work except in the subject matter." Its alliances are with such treatises as Casey's "Sequel to Euclid" and McDowell's "Exercises on Euclid and in Modern Geometry," but it appears to us to be better adapted in some respects than either of these works to the use of junior students. These are too condensed for some readers, whereas the book before us, without being too diffuse, enters into greater detail, and leads the pupil up, by a course of sound teaching, so as to enable him to attack with success the subject of modern analytical geometry. Mr. Dupuis looks at a triangle not as "the three-cornered portion of the plane inclosed within its sides, but the combination of the three points and three lines forming what are usually termed its vertices and its sides and sides produced." His object is to lead up to the idea of a figure as a locus, with a view to preparing the way for the study of Cartesian geometry. Here the necessity for a careful distinction between congruence and equality arises. He introduces freely the principle of motion in the transformation of geometric figures, and devotes some space to the principle of continuity. Further, he connects geometry with algebraic forms and symbols, "(1) by an elementary study of the modes of representing geometric ideas in the symbols of algebra, and (2) by determining the consequent geometric interpretation which is to be given to each interpretable algebraic form." The subject of proportion is treated on the method of *measures*, and the term *tensor* is freely used. The first part (pp. 1–90) traverses the point, line, parallels, the triangle and circle. The second part (pp. 91–146) considers the measurement of lengths and areas: each part closes with a section devoted to illustrative matter drawn from constructive geometry. The third part (pp. 147–177) consists of two sections—the first on proportion amongst line-segments, and the second on functions of angles and their applications in geometry. Some instruments are described, as the proportional compasses, the sector, the pantagraph, and the diagonal scale. In the fourth part (pp. 178–251) there are seven sections, which are taken up with such matters as the centre of mean position, inversion and inverse figures, pole and polar, radical axis, and centres and axes of perspective. The closing part (pp. 252–290) introduces the student to harmonic and anharmonic properties, polar reciprocals and reciprocation, and to homography and involution. The author discusses all these points in a lucid style, and illustrates them with full store of carefully selected solutions: in addition there are a great number of unworked exercises in all the subjects. These good results are the outcome of many years' teaching of geometry to the junior classes in the University of Queen's College, Kingston, Canada. The book is closed with a full index, and clearly drawn figures accompany the text.

A Vertebrate Fauna of the Outer Hebrides. By J. A. Harvie-Brown, F.R.S.E., F.Z.S., and T. E. Buckley, B.A., F.Z.S. (Edinburgh: David Douglas, 1889).

THIS is a sister volume to "A Fauna of Sutherland, Caithness, and West Cromarty," which was published by the same authors in 1887, and reviewed in NATURE at that time. It may be remembered that in the preface to this work, the authors expressed their intention of following it up with others, dealing in a similarly exhaustive manner with the vertebrate faunas of other parts of Great Britain. We are glad to receive at so early a date so substantial a fulfilment of this intention; for we cannot give higher praise to "A Fauna of the Outer Hebrides" than by saying that it is in all respects worthy of its predecessor. Moreover, when we have regard to the immense amount of labour which the production of these volumes must have involved, we cannot refrain from congratulating the authors on the rapidity with which their works have followed one another. This second member of the series runs to over 250 pages, and, like the first member, is embellished by a few beautifully executed drawings of landscape scenery. Like the first member, also, it gives an exhaustive account of all the Vertebrata which occur within the area specified, together with several introductory chapters dealing with the topography of the district, and the relation (palæontological and otherwise) of its fauna to that of the rest of Great Britain. As the value of such a work consists mainly in the number and the accuracy of its details, little need be said of it in a review, save in general terms. And, as we have already indicated, the painstaking labour which has been bestowed upon this Fauna appears to us to leave nothing that can be desired in the way either of addition or subtraction. We heartily recommend both these Faunas to all systematic zoologists, and sincerely hope that their authors may be able to continue their researches through other areas of Great Britain.

G. J. R.

Dictionary of Photography. By E. J. Wall. (London: Hazell, Watson, and Viney, Limited, 1889.)

THIS work is practically a complete encyclopædia o photography, and will form a very useful addition to photographic literature. It is written throughout in plain and straightforward language, each heading being thoroughly treated. The subject-matter under the heading of "Lens" is accompanied by excellent illustrations of the various forms of lenses, showing by shaded lines the different combinations of crown and flint glass. Developing, printing, &c., receive their full share in the work, and under "toning" no less than twenty-nine different baths are discussed. At the end there is a collection of miscellaneous tables that have not been inserted in the dictionary part of the book, such as sizes of French and Italian dry plates, a list of dry plates and sensitometer numbers, solubilities, freezing mixtures, &c.

For photographers in general this work ought to prove most useful. It will make it unnecessary for them to refer to other works for a hint or remedy, or anything else that may be wanted at a moment's notice.

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.*]

Upper Wind Currents over the Equator in the Atlantic Ocean.

IN January last I addressed you a letter from the Straits of Magellan, with an account of the upper wind currents observed over the equator during a voyage to South America in the month of December. Then I described how the north-east and south-east trades both turned into a common light surface easterly current along the line of the doldrums; how low clouds from south-east drove over the north-east trade up to 15° N.; how the highest clouds moved from south-west, north of the equator; and how, from 300 miles south of the line, a very high current from north-west prevailed over the south-east trade. No high observations were obtained in that belt of 300 miles, nor were any middle-level clouds seen over the south-east trade.

Now, I have just crossed the same route in the month of May, under a somewhat different wind system. The north-east trade turned to north as it approached the doldrums, instead of towards the east, as in the previous voyage. In the calm belt, it met a light easterly current, without much conflict in the way of rain; while further south the regular south-east trade was experienced as far as 8° S., when the north-east monsoon of the Brazilian coast prevailed nearly down to Rio Janeiro.

No signs of south-east wind could be discovered at any level over the north-east trade, which wind, on the other side, blew at low or middle levels over the south-east trade, till surface, low, and middle currents combined to form the Brazilian monsoon.

Very few observations were obtained of the highest clouds, but in 6° S. a high north-west prevailed; from 2° S. to the equator, both the middle and highest clouds came from the east; and nothing more could be determined till a high south-west current was found over the north-east trade, in 7° N. latitude.

These results confirm in a most striking manner the discovery which I have announced from time to time in your columns, and which was most conclusively proved by the labours of the

Meteorological Section of the Krakatão Committee of the Royal Society—"that the highest air-current over the equatorial doldrums is from the eastward, lying between the south-west current which flows on one side over the north-east trade, and the north-west current which flows on the other side over the south-east trade." RALPH ABERCROMBY.

21 Chapel Street, London, May 27.

The Structure and Distribution of Coral Reefs.

I HAVE to thank Prof. Bonney for pointing out my error in assigning the "90-fathom reef" to Socotra instead of to Rodriguez. It arose from my having been accustomed to associate Prof. Balfour's researches with the former island.

With regard to the depths in which coral reefs can form, there has been without a doubt some little concurrence of testimony as far as the evidence goes. But I contend that all the observers were misled by supposing that the sand and reef *débris*, that nearly always prevent and repress the growth of corals in depths of 20 to 30 fathoms, necessarily represented the lower limit of reef-formation. We know little of the depths beyond this belt of sand and reef *débris*, inasmuch as the observers in question rarely extended their search beyond. The difficulties in examining these depths are much greater, and systematic soundings are greatly needed, being in fact only practicable in the case of a surveying-vessel.

Since writing my letter I have received, through the courtesy of Captain Wharton, a copy of a report of the examination, in 1888, by Commander Moore and Dr. Bassett-Smith, of H.M.S. *Rambler*, of the slopes and zoological condition of the Tizard and Macclesfield Banks. This report is, I believe, to be further extended by Dr. Bassett-Smith, so I will only quote here the suggestive remark of Commander Moore, respecting the Macclesfield Bank: "Coral was found living as far down the slope as 44 fathoms; it may extend further, but darkness put an end to the work." I should also add that a living specimen of an astræan coral was brought up from a depth of 45 fathoms in the lagoon of Tizard Reef.

Through the agency of the officers of Her Majesty's surveying-ships, Captain Wharton will have soon at his disposal a large amount of new material throwing considerable light on the origin of coral reefs. H. B. GUPPY.

Atmospheric Electricity.

IN NATURE of May 16 (p. 55), Mr. Bowlker describes some "curious" and, as he believes, "rare electrical phenomena" which occurred to him and a friend on the Welsh mountains. Such phenomena are rare only because competent observers are so. The effects described are by no means uncommon, and they may be classed under the brush discharge and the glow, the one being an interrupted, and the other a continuous, discharge to the air.

H. de Saussure gives the results of his observations in America, Switzerland, and other places. He remarks that the lighting-up of the rocks at night is analogous to the curious fact of electricity moving over the prairies. It is compared to a kind of miniature lightning discharge, resulting from the electrified cloud brushing over the earth, and discharging itself in thousands of sparks coursing over the meadows. In Mexico he noticed the crepitation of the stones due to electrical discharges, and in Switzerland he describes certain pricking and burning sensations, and sounds like that of simmering water, emitted from sticks laid against the rocks, and from the tops of the alpenstocks. This humming of the mountains is by no means rare, and it seems to indicate a flow of electricity from the ground into the air.

When Prof. James Forbes was at work on the glaciers of Switzerland, he noticed on one occasion, near Mont Cervin, a curious sound proceeding from his alpenstock. The guide referred it to a worm eating the wood; he reversed the stick, and the worm was already at the other end. He raised his hand above his head, and the fingers yielded a fizzing sound, while the angular stones all round were hissing like points near an electrical machine. There was hail at the time, and a thunderstorm soon set in.

M. Trécul relates in the *Comptes rendus* the following curious case:—While writing at an open window in August 1876, between 7 and 8 a.m., he noticed a number of small luminous columns descend obliquely on his paper, each about 2 metres long, and half a decimetre broad at the widest part, obtuse at the farther end, but gradually thinning towards the table. They had mostly a reddish-yellow tint, but near the paper the tints were more intense and varied. In disappearing they left the paper with a slight noise, like that produced by pouring a little water on a hot plate. Loud thunder was heard at the time of the observation.

In June 1880, at Clarens, near the Lake of Geneva, a cherry-tree was struck by lightning, and a little girl who was about thirty paces from the tree appeared to be wrapped in a sheet of fire, while six persons, in three groups, none of them within 250 paces of the cherry-tree, were enveloped in a luminous cloud. They said they felt as if they were being struck in the face with hailstones or fine gravel, and when they touched each other, sparks passed from their fingers' ends. At the same time a luminous column was seen to descend in the direction of Chatelard, and it is stated that the electricity could be distinctly heard as it ran from point to point of the railing of the cemetery.

Mr. Jabez Brown, while ascending one of the sharp hills near Boscastle, in November, at 9 p.m., was suddenly surrounded by a bright and powerful light, which passed him a little quicker than the ordinary pace of a man's walking, leaving it as dark as before. The light was seen by the sailors in the harbour, coming in from the sea, and passing up the valley in a low cloud. A similar one occurred in Scotland last year.

Highgate, N. C. TOMLINSON.

THE electrical phenomenon described by Mr. Bowlker in NATURE of May 16 was doubtless an instance of St. Elmo's Fire; and if it had been dark at the time it was noticed, the post, walking-stick, and other objects affected by it would have been seen to be capped with a glow resembling somewhat the *brush-discharge* of an electrical machine. It has been observed about fifteen times on the summit of Ben Nevis during the last five years, and these cases are described, and the accompanying weather discussed, in a paper by Mr. Rankin, of the Ben Nevis Observatory, published in the last number of the Journal of the Scottish Meteorological Society. When it occurs, all elevated points, whether metallic or not, glow; the light in the more intense cases being several inches in length. It is almost always accompanied by a heavy fall of conical-shaped snow-flakes about a quarter of an inch long, resembling hailstones in shape, but not hard or icy. At all times when it has been seen the barometric pressure has been high over the south or south-west of Europe, and low to the north of Scotland, thus giving steep gradients for westerly winds; and in most cases the temperature on Ben Nevis has been falling, while the barometer after falling considerably has begun to rise again, and the wind to veer from south-west towards north-west. R. T. OMOND.

Ben Nevis Observatory, May 24.

Sailing Flight of the Albatross.

MY attention has been drawn to some correspondence in NATURE, May 2 and 9, on the "Sailing Flight of the Albatross," in which reference is made to my father's letter to Sir William Thomson on the subject. At Sir William Thomson's suggestion, I am now about to condense the rest of my father's correspondence on the subject into a form convenient for publication. In the meantime I will only say that while Mr. Baines's very interesting letter, and his explanation of the phenomenon of "soaring," appear to me perfectly sound in principle (and indeed we have Lord Rayleigh's authority for this view), my father's statements seem to prove that his own solution is also the true explanation of the soaring under the (different) circumstances in which he observed it. It appears to me only reasonable to suppose that the birds instinctively learn to avail themselves of *all* the different natural conditions which under different circumstances may serve them to maintain their flight with the smallest exertion. R. E. FROUDE.

Gosport, May 25.

The Science and Art Examination in Physics.

THE paper set on May 17, in Sound, Light, and Heat, presents several features that must have created dissatisfaction alike among students and teachers.

First, the official Syllabus explicitly states that the paper "will be so arranged that a candidate can secure a first class in either stage by taking up *two* only of the subjects." This has been so for some years past, and there have always been *five* questions in each subject. As the maximum number of questions a candidate may attempt is eight, this gave a choice in each subject of four questions out of five. But this year, without any previous notice, the number of questions in each subject is reduced to *four*, so that a student who only takes up two of the subjects has absolutely no choice. He may be well prepared, yet if he happen to have overlooked *one* of the points dealt with in the questions, his chance of a first class is seriously diminished.

In making this unlooked-for change, the Department practically takes away with one hand what it gives with the other.

Secondly, in the advanced paper, the second question in Sound runs thus: "If a string 24 inches long weighs half an ounce, and is stretched with a weight of 81 pounds find its rate of vibration when bowed or struck."

Now this is a problem not on *comparative* measurements, which are fairly within the grasp of an advanced student, but on *absolute* measurements. To solve this question requires a knowledge not merely of the principles of sound, but also of theoretical mechanics and of numerous mathematical details, besides considerable dexterity in manipulating units, which is about the most perplexing thing a student ever encounters, and has hitherto never been called for except in the honours stage.

To set such a question as one of *four*, and offer no choice, is in effect to condemn the students at the outset, and must have a most depressing effect upon the classes in future years. At any rate, if the Department intended to introduce absolute measurements into the advanced stage, it is only fair that they should have given notice.

Thirdly, the last question in Heat (advanced) asks the student to "sketch an apparatus for determining the *coefficient of expansion* of a gas at constant *volume*." Perhaps the examiners will kindly inform us how a gas can expand, its volume at the same time remaining constant. Possibly the word "expansion" is a misprint for "increase of elasticity," in which case Balfour Stewart's apparatus should be sketched; or, possibly the word "volume" is a misprint for "pressure," in which case Gay-Lussac's apparatus is required; or, possibly there is an intentional confusion of phraseology in order to perplex the candidates.

Misprints occur in one or more papers nearly every year. Last year there was an error in Mathematics, Stage 3, when a certain equation was printed with the figure 4 instead of 1, thus causing candidates to waste time and become flurried, and here again we have the same kind of thing.

A SCIENCE TEACHER OF SEVEN YEARS' STANDING.

May 21.

DR. NANSEN'S JOURNEY ACROSS GREENLAND.

FROM a communication sent us by Dr. Nansen, we are able to give some details of the remarkable journey across Greenland which he accomplished last summer. We need only briefly recall the most important attempts which had previously been made to cross a country which is exactly in the condition of our own islands during the Glacial period. The first serious attempt was made in 1878 by Jensen and Steenstrup, who, from the west coast in lat. 62° 30′ N., managed to get some 40 miles into the interior, after many difficulties and dangers, ascending a mountain to a height of 5000 feet, from which they saw the inland ice rising gradually towards the interior. Then came the famous expedition of Baron Nordenskiöld in 1883. He, with a comparatively large party, started much further north than the previous expedition, a short distance south of Disco Island. The party succeeded in penetrating some 90 miles eastwards, to an altitude of 5000 feet. The Laplanders, however, who accompanied Nordenskiöld went in their snow-shoes 140 miles further, travelling over a continual snow desert to a height of 7000 feet. The next serious attempt was made by an American, Mr. R. E. Peary, in the summer of 1886. Mr. Peary started much further to the north than Nordenskiöld, and his course was due east. He reached 100 miles from the edge of the ice-blink, or inland ice, his highest elevation being 7525 feet.

Dr. Nansen felt sure that the only way to cross the ice was by means of *ski* (a special kind of long snow-shoe) and sledges. He had many applications to be allowed to accompany him; but he selected only five companions—a lieutenant in the army, a shipmaster, a Norwegian peasant, and two Lapps. The expenses of the expedition were generously supplied by Mr. Augustin Gamel, of Copenhagen. The party left Christiania early in May 1888 for Iceland, whence they embarked on board a sealer for the east coast of Greenland. Dr. Nansen's own account of his attempts to land is of interest as showing the condition of the ice and the currents off the East Greenland coast:—

"On June 4 we left Iceland in the *Jason* for Greenland. My hope was that early in June we should be able to reach the coast in the neighbourhood of Cap Dan, in latitude about 65° 30′ N.; but I was disappointed, as large masses of ice stopped us at a distance of 50 miles from the coast. At last, on July 17, we approached the land at the Termilik Fjord, west of Cap Dan, and I determined to leave the ship. In our two boats we had to force our way about ten miles through the ice. The current was, however, very strong, the ice-floes were thrown and pressed against each other, and during such a pressure of the ice one of our boats was broken. We were then very near to the coast, but the boat could not float, and some hours passed before the leak could be restored. In the meantime, the ice was very much pressed, and we went adrift, the speed with which the current carried us off from the coast being much greater than that with which we could advance on the ice. At the great rate of about 28 miles each twenty-four hours we were driven southwards along the coast. We tried to reach land three times, but by a rapid current we were again carried towards the sea.

"At last, on July 29, we succeeded, and reached land at Anoritok, 61° 30 N. lat. Originally, I had thought to land at Inigsalik, in 65° 30′ N. lat. We had consequently come 240 miles too far southwards. Our destination was Christianshaab, in Disco Bay, to reach which we should be obliged to go in our boats northwards, to cross the continent at a more northerly latitude. To get northwards was not, however, very easy. Masses of Polar ice were pressed towards the land, and very often the axe alone could break a way through the tightly pressed ice-floes."

Two parties of heathen Eskimo were met with, who were at first rather distrustful of the strangers, as they had scarcely ever before seen Europeans.

On August 10 (more than a month behind time) the party reached Umiavik, 64° 30′ N., whence the start was to be made across the inland ice. Dr. Nansen and Captain Sverdrup the next day made an excursion to examine the glacier. They got ten miles from the coast, and reached a height of 3000 feet. On August 15 a start was made, there being five sledges to pull, one loaded with 400 pounds, pulled by Dr. Nansen and Captain Sverdrup. Two days later they were stopped by a heavy gale which kept them in their tents for three days. At first the intense heat compelled them to travel only at night. Dr. Nansen goes on to say:—

"At some distance from the coast the snow became, however, very deep and bad for pulling. We were also met by a heavy gale from the north with snow-drift, so that we could advance only very slowly. I hoped that it would soon become better, but each day it became worse. It was only too clear that if it continued in this way we would not be able to reach Disco Bay till the middle of September, when the last ship left for Europe. Though I expected to find more difficult ice in this direction, I changed our route and turned towards Godthaab. That was on August 27. We had then reached about 64° 50′ N., about 40 miles from the coast, and a height of about 7000 feet. By this change of direction, the wind became so favourable that we could use sails on the sledges, and thus they became less heavy to pull. In this manner we advanced during three days, then the wind went down, and we were obliged to lower our sails.

"In the beginning of September we reached a quite flat and extensive plateau, which resembled a frozen ocean. Its height was between 8000 feet and 9000 feet, though towards the north it seemed to be considerably higher. Over this plateau or highland we travelled more than two weeks. The cold was considerable. I am not, however, able to give an exact statement of the temperature, as our thermometers did not go low enough. I believe that on some nights it was between -45° and -50° C. (between 80° and 90° F. below freezing point) In the tent where we (six men) slept, and where we cooked our tea and chocolate, it was even less than -40° C. (72° F. of frost). During one month we found no water. To get drinking-water we were obliged to melt snow either in our cooking apparatus or by our own warmth in iron bottles, which were carried inside our clothes on our bosoms. The sunshine on these white snow-fields was bad for the eyes, but no case of snow-blindness occurred. Only one day, September 8, we were stopped by a snowstorm; the next day, when we wanted to continue our journey, we found the tent was quite buried in the snow.

"On September 19, we got a favourable sailing wind, and then we advanced very rapidly. That day we got the first sight of the mountains of the west coast. In the night we were stopped by dangerous ice with many crevasses, after having very nearly lost several men and sledges in one of them. We met here with very difficult and uneven ice, where we advanced very slowly. At last on September 24, we reached land at a small lake to the south of Kangersunok, a fjord inside Godthaab. On September 26, we reached the sea at the inner end of the Ameralik fjord, in 64° 12′ N. latitude."

This really finished the journey across Greenland. With considerable difficulty the party reached Godthaab, where, as the last ship was gone, they had to spend the winter, reaching Copenhagen only last week. So far Dr. Nansen has not been able to tell us much more than we knew already about the interior ice of Greenland; though he will probably give us full details in the paper which he is to read at the Royal Geographical Society on June 24.

ON THE TELLURIC ORIGIN OF THE OXYGEN LINES IN THE SOLAR SPECTRUM.[1]

M. EIFFEL having very obligingly put the tower in the Champ-de-Mars at my disposal for any experiments and observations that I cared to make there, I decided to take advantage of the powerful electric light which had been installed, to make certain studies of the telluric spectrum, and, in particular ,that which relates to the origin of the lines of the spectrum of oxygen in the solar spectrum.

We know now that there exist in the solar spectrum many groups of lines that are due to the oxygen contained in our atmosphere; but one may ask himself whether these groups are due exclusively to the action of our atmosphere, and the solar atmosphere between counts for nothing, or whether their origin is double—in a word, Are these groups purely telluric or telluric-solar?

To settle this question, one may have recourse to a certain number of methods. One of the most trustworthy is that of displacement, the origin of which rose from the beautiful conception of M. Fizeau, and which has been applied by M. Thollon and perfected by M. Cornu.

[1] Translation of a paper read by M. J. Janssen before the French Academy of Sciences on May 20, 1889 (*Comptes rendus*, cviii. No. 20).

The application of this was too difficult in the present case.

We may also observe the diminution of intensity which the groups undergo when we ascend in the atmosphere, and by careful comparisons when possible, and especially by a great number of observations, we may judge if the diminution of the intensity of the lines would permit us to conclude that they would completely disappear at the limits of the atmosphere. This is the method employed in the last Mont Blanc expedition (Grands-Mulets). Or, we may again proceed with a comparison of the uniformity of the lines by installing a powerful light giving a continuous spectrum at such a distance that the thickness of atmospheric air traversed may have the same action as that of the terrestrial atmosphere on the rays of the sun, when it is near the zenith.

This last circumstance is very fortunately found realized in the respective situations of the Eiffel Tower and the Meudon Observatory. The tower is at a distance from the Observatory of about 7700 metres, which very nearly represents the thickness of an atmosphere having the same weight as the terrestrial atmosphere and a uniform density, and equal to that of the atmospheric layer traversed by the sun's rays.

In addition to this, the considerable power of the magnificent light actually installed on the summit of the tower permits the employment of the instrument that had served me at Meudon and at Grands-Mulets for the sun. I have, however, made use of a condensing lens in front of the slit in order to give the spectrum an intensity quite comparable to that of the solar spectrum in the same instrument.

Under these conditions the spectrum is shown with extreme vividness, and extends beyond A. The B group appeared to me as intense as with the sun on the meridian in summer. The A group was equally well defined. Other groups could be distinguished, and notably those of water-vapour, their intensity showing the hygrometric state of the column of atmosphere traversed.

I should have liked to study the oxygen groups with the great spectrometer of MM. Brunner and a Rowland's grating, but the limited time during which the light was turned on to me did not permit it. I hope to do so another time.

Not one oxygen band is seen in the visible spectrum, although the thickness of the layer of oxygen traversed was equivalent to a column of more than 260 metres of oxygen at a pressure of six atmospheres—that is to say, at the pressure under which the tube in our laboratory shows them with a length of only 60 metres, or four times as small. This well shows that, for oxygen, the lines follow an entirely different law from the bands.

Indeed, whilst for the lines the experiment of last Sunday shows us that it appears indifferent whether we employ a column of gas at constant density or a column equivalent in weight but with variable density; for the bands, on the contrary, the absorption taking place following the square of the density, the calculation shows that there would be required, at the surface of the sun, a thickness of atmosphere of more than 50 kilometres to produce them.

I do not look upon the experiment of last Sunday as more than bringing forward a fact more to a group of studies—a fact which requires to be exact and developed. But it is certain to myself, that the height at which the tower of the Champ-de-Mars makes it possible to place the light source, and its power, will enable me to make other similar experiments of higher interest.

Before concluding, I wish to thank M. Eiffel for the liberality with which he put his beautiful edifice at the disposal of science. I equally thank MM. Sautter and Lemonnier for their kindness.

THE ZOOLOGICAL SOCIETY'S INSECT HOUSE.

ALTHOUGH it has long been the practice of entomologists to keep private collections of the larvæ of insects, for the purpose of studying their metamorphoses and of obtaining perfect specimens of their fully-developed forms, there is, we believe, still only one place where the attempt is made to attract public attention to this most varied and wonderful group of animals by an exhibition of them and of the different stages of their life-history. This place is the Insect House of the Zoological Society of London in the Regent's Park Gardens, which has now been maintained with considerable success for several years.

At this season of the year the Insect House is generally at its best, and examples of the perfect insect are continually to be seen emerging from the chrysalis.

Leaf-insect of the Seychelles (*Phyllium gelonus*).

A very interesting and novel addition has just been made to the collection in the form of a specimen of one of the Leaf-insects, presented by Lord Walsingham, who received it from the Seychelles Islands through Colonel Larking. Though not yet fully developed, there can be no doubt it will prove to be an example of *Phyllium gelonus*, Gray. The insects of this remarkable genus are all Oriental, inhabiting the tropical regions of Asia, and extending to Mauritius and the Seychelles. It has hitherto proved impossible to induce them to continue their species in this country beyond a single generation, so that it is only occasionally that they can be seen alive here. So long ago as 1854 a living specimen of an Indian species, *P. scythe*, was exhibited in the Botanic Gardens at Edinburgh, where it attracted so much attention that it was found necessary to limit its exhibition to four days in each week. This restriction was (as stated by Murray) adopted because, in spite of the old saying that seeing is believing, it was found in the case of this insect that seeing was disbelieving. On those who inspected it insisting that there was no insect on the plant, but only a leaf, it had to be stirred up to convince them of the truth, and this process of continual provocation was found to be very injurious to the constitution of so peaceable a creature.

The resemblance of many of the species of this group of Orthoptera to portions of the plants on which they are found is so extreme that it has given rise to a firm conviction in the minds of the inhabitants of some of the regions in which they are found that they are portions of the actual plant transformed into living insects. There is certainly more to be said for the belief in this metamorphosis than there is for some of the transformations related by Ovid; and M. de Borre, in the *Comptes rendus* of the Belgian Entomological Society (1883), has explained the reasoning by which it is justified. The people having observed the gradual growth of the creature and the development of the appendages of the body, while they have failed to see it when very small and issuing from the egg, maintain stoutly that a young leaf gradually grows into a living insect. The species of the genus *Phyllium* all have a remarkable resemblance to leaves, but it appears as yet not to be known whether the different species have a special resemblance to the foliage on which they feed.

The late Andrew Murray published an account of the Edinburgh specimen in the *Edinburgh New Philosophical Journal* for 1856, and then said that he "should not be at all surprised if, in the course of a few years, the Leaf-insect should be as common an inmate of our conservatories as the canary-bird now is of our dwellings." This hope has, however, not been realized, and for our opportunities of seeing it in the living state we are obliged still to rely on the kindness of naturalists who may be stationed in the tropical regions where these creatures exist, and who will take the trouble of bringing or sending them or their eggs over to us. The difference between a living and a dead insect is not so extreme as that between a live dog and a dead dog, but still it is very great, and one of our older entomologists used to say that he never really knew the species of an insect till he had seen it alive.

The Insect House in the Zoological Gardens affords, as we have said, the only opportunity that the English public have of seeing alive some of the wonderful forms of tropical insects. But, as we have already remarked, the difficulty of perpetuating the life of these examples of exotic Nature's variety and luxury beyond a short period is excessive, and reaches its maximum in London. There is, perhaps, nothing more remarkable in Nature than the pertinacity and rapidity with which the generations of many of the lower forms of insect life are produced. *Phylloxera*, *Aphis*, scale-insects almost defy the efforts of mankind to control them, and the resources of even scientific civilization contend with them as yet almost in vain. But in many of the more evoluted forms of insects we find a very different condition prevalent. Even mating can, in a large number of cases, be induced only when the creatures are placed in exactly appropriate circumstances, and afterwards the insects will only deposit their eggs in such places and under such conditions as insure at least a probability of congenial existence for their progeny. In the case of many species the females prefer to die with their eggs undeposited, rather than place them in conditions that are at all inappropriate. Thus the difficulty of keeping up a varied supply of curious forms for the Insect House is very great.

The different kinds of silk-producing moths have attracted much attention for a considerable number of years past, and in the case of several species fertile eggs are readily procured. These insects, being in many cases very large and attractive creatures, excite a good deal of interest in the visitors to the Insect House. Just at present these moths are about commencing their individual life-cycles afresh; eggs of several species have been procured, and will shortly be hatched. The caterpillars are even more interesting than the moths themselves, and their remarkable shapes and forms, and their wonderful spines and thorns, are of much interest to naturalists. Just now, too, there may be seen in the Insect House a delightful example of the early stages of insect-life in the form of the caterpillar and chrysalis of *Limenitis disippus*. This is a North American butterfly, the egg of which is hatched towards the end of summer or in autumn. Its young larva constructs for itself a delicate habitation by joining together the edges of the leaves of the willow on which it feeds, so as to form a cylindrical tube, which it lines with silk and closes at one end. The fragile creature is thus able to outlive the storms of wintry wind and weather, and to evade the ravagers of the animal world in search of food. In the protection of this dwelling it can be transmitted from North America to this country without injury to its vitality. As seen in the Insect House, the caterpillar is a curiously mottled, pale-brown, greenish and grey creature, with head bent down, but bearing on the prominent part just behind it two rather long, erect, slender horns of a deep black colour, each of them numerously spined. The chrysalis is even more remarkable, and hanging down from a twig displays itself in a very prominent manner. On the middle of its body there is an abrupt, elongate, black hump, about as conspicuous a deformity as could be devised, while at the base of this, on each side, there is a band of delicate and beautiful metallic colour. This band is in some way dependent for its tint on the living creature within, for no trace of it can be seen in the pupa-shell after the insect has escaped. This species of butterfly belongs to the family *Nymphalidæ*. The extraordinary spines of the caterpillars of this group have recently been studied, and many of them delineated, in an elaborate and interesting memoir by W. Müller, which will be found in the first volume of the *Zoologische Jahrbücher*.

The Diurnal Lepidoptera are not so well represented in the Insect House as they usually are at this time of year, there having been a great scarcity of pupæ last summer. But, besides the *Limenitis* above referred to, examples of one of the Swallow-tails (*Papilio machaon*), and of one of the large North American Skippers (*Gonioloba tityrus*), are now daily emerging from their pupa stage, and fresh additions are shortly expected.

NOTES.

WE are glad to learn, from the list of birthday honours, that the Companionship of the Bath has been conferred on Dr. James Bell, F.R.S., and the Companionship of St. Michael and St. George on Mr. Ellery. A baronetcy has been granted to Prof. Stokes; but, seeing that Prof. Stokes has been for many years President of the Royal Society, and that the Government never thought of offering him any special honour until he entered the House of Commons, we may conclude that he receives his baronetcy not as an illustrious investigator, but as a politician.

ON Saturday, Sir Frederick Bramwell, as President of the British Association, entertained the President-Elect, Prof. W. H. Flower, C.B., F.R.S., a large number of members of the Association, representatives of science, and other guests being invited to meet him. The dinner was given in the hall of the Goldsmiths' Company, the use of which was granted to him for the purpose by the Wardens of the Company. The list of guests included Lord Bramwell, F.R.S., Mr. Justice Denman and Mr. Justice Manisty, Mr. C. Lucas, Prime Warden of the Goldsmiths' Company, the Mayors of Newcastle and Gateshead, Sir F. A. Abel, C.B., F.R.S., Captain Abney, R.E., C.B., F.R.S., Prof. Roberts-Austen, F.R.S., Prof. Ayrton, F.R.S., the Ven. the Archdeacon of Bath, Sir I. Lowthian Bell, F.R.S., the Rev. Prof. Bonney, F.R.S., Sir J. Crichton Browne, F.R.S., Mr. Brudenell Carter, Mr. C. Cochrane (President of the Institution of Mechanical Engineers), Sir John Coode, K.C.M.G., Mr. W. Crookes, F.R.S., Prof. Boyd Dawkins, F.R.S., Prof. Dewar, F.R.S., Sir James Douglass, F.R.S., Mr. W. T. Thiselton-Dyer, C.M.G., F.R.S., Dr. John Evans, F.R.S., Mr. Francis Galton, F.R.S., Dr. Gamgee, F.R.S., Dr. Geikie, F.R.S., Mr. R. Giffen, Mr. Alfred Giles, M.P., Dr. Gladstone, F.R.S., Mr. G. B. Gregory, Mr. Thomas Hawksley, F.R.S., Prof. Henrici, F.R.S., Mr. Victor Horsley, F.R.S., Major-General Hutchinson, R.E., Prof. Judd, F.R.S., Colonel Laurie, C.B., M.P., Prof. Liveing, F.R.S., Mr. J. Norman Lockyer, F.R.S., Prof. McLeod, F.R.S., Major Marindin, R.E., Mr. Ludwig Mond (President of the Society of Chemical Industry), Mr. J. Fletcher Moulton, Q.C., F.R.S., Admiral Nicholson, C.B., Admiral Sir E. Ommanney, C.B., F.R.S., Sir P. Cunliffe-Owen, K.C.B., K.C.M.G., Dr. William Pole, F.R.S., Mr. W. H. Preece, F.R.S., Colonel Rich, R.E., Prof. Romanes, F.R.S., Sir H. E. Roscoe, M.P., F.R.S., Prof. Rücker, F.R.S., Dr. Russell, F.R.S. (President of the Chemical Society), Prof. J. S. Burdon Sanderson, F.R.S., Prof. Schäfer, F.R.S., Dr. P. L. Sclater, F.R.S., Sir William Thomson, F.R.S., Sir William Turner, F.R.S., Major Tulloch, R.E., Sir C. W. Wilson, R.E., K.C.B., K.C.M.G., Sir Francis de Winton, K.C.M.G., Mr. E. R. Wodehouse, M.P., and many others. In England, which in this respect differs widely from the other leading countries of Europe, men of science, including even those in State employ, are not invited to take part in such State functions on the birthday dinner. It was a happy thought on Sir Frederick Bramwell's part, therefore, to select the Queen's birthday as the day on which his dinner was to be given. Many of the most eminent men of science in the country had thus an opportunity of associating themselves with the expression of the general feeling of the community on an interesting public occasion. By this time it should surely be manifest to everyone that, on all such occasions, science should be prominently represented. The State has nothing to lose, but, on the contrary, has much to gain, by the full recognition of science as one of the most vital elements of national progress.

THE gold medal of the Linnean Society has been awarded this year to Prof. de Candolle, the eminent botanist, in recognition of his distinguished services to botanical science.

IN his Presidential address, delivered at the anniversary meeting of the Linnean Society on the 24th inst., Mr. Carruthers gave an interesting and detailed account of the existing portraits of Linnæus, many of which are in the Society's possession. The result of his inquiries showed that there are seven original and authentic portraits of Linnæus in existence; that the engravings most widely known are from the originals by Inlander and Roslin; and that these give the most faithful representation of the features of the great naturalist.

A NEW departure, likely to be productive of far-reaching results, has recently been taken in connection with the scientific work of the Scotch Fishery Board. Since 1809 the Scotch fisheries have been under special supervision, and at one time the Scotch fishery statistics were in advance of those of any other country. Previous to 1882 occasional scientific inquiries were made by Sir Lyon Playfair and Prof. Allman, and since 1882 investigations have been systematically carried on under the direction of Prof. Ewart and Sir James Maitland. Year by year the scientific work has been extended, and for some time a scientific department has existed in everything but in name.

This department, which seems to enjoy the confidence of the Scotch Office, and all the assistance the importance of the fisheries demands, has now been fully recognized and strengthened by the formation of a Committee of advice and reference, which includes representatives from all the Scotch Universities, and, in addition, an eminent statistician and the distinguished Director of the Edinburgh Science and Art Museum. The Committee, which is expected to advise as to technical and statistical as well as biological and physical questions, consists of Profs. Bayley Balfour, Crum Brown, Dittmar, D'Arcy Thompson, McIntosh, McKendrick, McWilliam, Traill, and Young; Sir R. Murdoch Smith, and Mr. G. A. Jameson. Those responsible for the formation of this Committee are to be congratulated, not only for the bold and enlightened policy displayed, but also for enlisting the active interest of so many distinguished men in the Scottish fisheries. The willingness of the members of this Committee to co-operate with the present directors of the scientific work is the best guarantee that their past labours have been appreciated, the best reward for surmounting the many difficulties that have necessarily been met with in initiating and carrying on fishery investigations.

MR. RICHARD BULLEN NEWTON, of the Geological Department, British Museum, has been presented to an Assistantship of the first class.

MR. MELLUISH succeeds the late Mr. Johnston as Electrician to the Government of India.

MR. HALY, Curator of the Colombo Museum, has published a "first report" on the collection of moths in the Museum. It is compiled from Messrs. Coles and Swinhoe's catalogue of the moths of India and Ceylon, and Mr. Haly has added all that is at present known concerning their local distribution and the times of the year at which the species appear.

THE Johns Hopkins Hospital, Baltimore, was opened on May 7. An address was delivered on the occasion by Dr. Daniel C. Gilman, who spoke eloquently of the close relationship between the advancement of knowledge and the progress of charity.

MESSRS. TRÜBNER have issued the first number of what ought to be a useful monthly periodical—*The Periodical Press Index*. The aim of the editor is to present a record of the more important subjects dealt with in periodical literature at home and abroad. As it would become irksome in course of time to consult a monthly index, arrangements are being made for the publication of an additional yearly volume on a plan which will render it unnecessary for students to refer to each part month by month.

PROF. H. G. SEELEY, F.R.S., will conduct the London Geological Field Class to sections on the North Downs, showing Gault and Lower Greensand, on Saturdays in June and on Whit Monday. Communications should be addressed to the Hon. Sec., Mr. R. H. Bentley, 31 Adolphus Road, Brownswood Park, South Hornsey.

A NEW substance, singular alike in its chemical nature and in its properties, has been discovered by M. Péchard. It is a mixed acid derived from oxalic and molybdic acids, and is therefore termed oxalomolybdic acid. It is a solid, crystallizing in large monoclinic prisms, and forms a well-defined series of salts. Berzelius long ago found that molybdenum trioxide readily dissolved in a hot solution of oxalic acid, but appears never to have investigated the nature of the reaction. When the molybdic acid has been added almost to saturation the liquid becomes syrupy, and on evaporation yields crystals of the new oxalomolybdic acid, which on analysis give numbers corresponding to the formula $C_2H_2O_4 . MoO_3 . H_2O$. The finest crystals are obtained by dissolving the viscous mass, formed on evaporating the saturated solution of the acid, in dilute nitric acid, and allowing it to evaporate in a desiccator. Oxalomolybdic acid is almost totally insoluble in strong nitric acid, and if an excess of nitric acid be added to a saturated solution of the new acid, small crystals at once separate; but if dilute nitric acid be employed, the crystals form more slowly, and are consequently much larger and more perfect. The crystals dissolve in cold water, more rapidly on warming, yielding a colourless and strongly acid liquid. That it is a true mixed acid is shown by the fact that it forms crystalline salts with metals. If a solution of silver nitrate is added to a warm solution of the acid in water, a yellow crystalline precipitate of the silver salt, $C_2Ag_2O_4 . MoO_3$, is thrown down. This salt is insoluble in water, but, like many other silver salts, is readily dissolved by ammonia. Barium chloride or baryta water precipitate in a similar manner the barium salt $C_2BaO_4 . MoO_3$, in the form of small colourless crystals. The sodium salt, $C_2Na_2O_4 . MoO_3 . 5H_2O$, is readily obtained in good crystals by neutralizing the acid with soda. The crystals of oxalomolybdic acid, when dry, may be preserved unchanged either in sunshine or in the dark. But, if moist, they quickly become coloured blue when exposed to the sun's rays. If characters be written on paper with the solution, they remain invisible in a weak light; but, when exposed to sunshine, they rapidly become visible, turning to a deep indigo colour. It is curious that this effect only happens when the solution is spread over paper or other surfaces, for the solution itself may be kept unaltered in the bottle for any length of time, except for a trace of blue at the edge of the meniscus, where, by surface action, a little is spread against the interior glass walls. If a sheet of paper be immersed in a saturated solution of the acid, dried in the dark, and then exposed behind an ordinary photographic negative, a very sharp print in blue may be obtained by exposure to sunlight for about ten minutes. The colour instantly disappears in contact with water, so that if a piece of this sensitized paper be wholly exposed to sunlight, one may write in white upon the blue ground by using a pen dipped in water. If, however, the paper with its blue markings be exposed to a gentle heat for a few minutes, the blue changes to black, and the characters are then no longer destroyed by water.

THE Pilot Chart of the North Atlantic Ocean for the month of May shows that the month of April commenced with generally high barometer and moderate weather over the greater part of the trans-Atlantic routes, followed by easterly gales on the 3rd, and continuing in the eastern regions until the 11th. On the 7th and 15th, areas of high barometer left the American coast, and slowly traversed the ocean, reaching Europe on the 15th and 26th respectively. Several storms visited the American coast, one off Hatteras on the 7th and 8th being of marked severity, causing the water to rise a foot higher than ever known before at Norfolk, and doing great damage both on shore and at sea. There was a great increase of fog, especially off the coast of the United States. A large iceberg was seen on the 9th, in lat. 48° N., and long. 44° 40′ W.

A LIMITED number of copies of the first part of the "Bibliography of Meteorology," which has been for many years in course of preparation by the Washington Signal Office, has been issued in a lithographic form by General Greely. It contains 382 quarto pages, and includes all the titles of books and articles bearing upon the subject of temperature from the origin of printing to the close of 1881. Similar titles covering the period from 1882 to 1887 have also been prepared, but are not included in the present volume. The classification of the titles is based upon a scheme furnished by Dr. A. Lancaster, of Brussels, and is arranged under nineteen subdivisions, the arrangement of each subdivision being chronological under the authors' names, and, at the end, a list of authors' names is given, with references to the pages on which their works are found. We think that, considering the large amount of materials to be dealt with, this is the best arrangement that could be made, although, whenever a minor classification is attempted, it invariably leads to difficulties of arrangement, and to corresponding difficulties in turning up any particular work. We should like to have seen some reference to the libraries in which the older works are to be found, as has been done for all titles given in the Brussels catalogue. The work is one of the greatest importance to all meteorologists, and we can only hope that the favourable reception it is sure to meet with in all countries will induce Congress to order its regular publication, and that of the volumes relating to all other meteorological subjects, the materials for which are already prepared. It was on this distinct understanding that Mr. G. J. Symons handed over his 20,000 titles to General Hazen, some years ago.

AT a recent meeting of the New York Academy of Sciences, General Andrews, commenting on a paper about the proposed Tehuantepec ship railway, made some interesting remarks on the general subject of ship railways. Estimates which he regards as incontrovertible show that a ship can be hauled by a locomotive over a ship-railway, or, as he prefers to designate it, a ship-tramway, with the expenditure of only one-half the amount of coal which the same ship must burn to propel herself through the water of a canal. The most frequent objection urged against the practicability of the scheme is that it would rack the ship; but General Andrews explained that the weight is so distributed among the numerous supports that no one need sustain a greater weight than a man presses upon his foot in walking. The gradients of the route will be very slight, not exceeding 2 inches in 400 feet, the entire length of a vessel. He had made observations, during a voyage aboard the steamer *Britannic*, to measure the amount of strain to which she was exposed in a sea of no very great roughness, and found by stretching cords that the steamer was bent sixteen inches by the waves, but without the slightest injury: hence he infers that the stress on a vessel in crossing the isthmus would be inappreciable and harmless.

MR. ALEXANDER DURLACHER has presented to the Royal Colonial Institute an interesting collection of native weapons and implements from Western Australia.

A RESOLUTION has been issued by the Government of India, dealing with the preservation of antiquarian treasures, with the view of making known the conditions under which the Government can claim articles of archæological interest, and to provide for their better preservation for the public by holding out the prospect of sufficient reward to finders of treasures. The resolution lays especial stress on the importance of paying proper consideration to the claims and expectations of these latter, as the end in view will be defeated if those who discover objects of antiquarian value are not induced by the hope of sufficient reward to make their discoveries known to the public authorities.

CAPTAIN A. P. MADSEN lately communicated to the Northern Antiquarian Society of Copenhagen an account of his examination of the celebrated great "kitchen-midden" at Meilgaard, in Jutland, which has only once before (in 1869) been slightly examined. It is now situated several miles inland, but the configuration of the country showed that at the time of its formation a bay existed there. The midden was at one time some 12 feet in depth, but is now only 6. Oyster-shells predominated, then came the common blue mussel and winkles. There were also shells of three kinds of other mussels, of which two are extinct, but the third species is still found in the Limfjord. There were three places with remnants of charcoal and ashes. The bones found were those of water rats, ring seals, grey seals, dogs, pigs, foxes, martens, otters, boars, roe-deer, stags, bullocks; common swans, wild ducks, the great loon, sea-gulls, ring-doves, and crows; and of fishes, those of salmon, jack, eel, cod, and flounder. Of implements from the Stone Age were flint chisels, hooks of bone, a flint wedge, arrow-heads, drills, &c. The quantity of the remains indicated that a considerable population had lived in the vicinity, who no doubt brought the spoils of the chase thither. The land was now 20 feet above sea-level, but there was every appearance of the site having once been on a promontory by the sea. Many of the middens in Jutland were now situated from five to six miles inland, but had undoubtedly once lain by the sea. In one midden, Captain Madsen had found split marrow-bones, ornamented pottery, and polished implements, together with bones of sheep and goats, but no marine shells, indicating that there were also middens from a more recent period. Commenting upon these explorations, Prof. Japetus Steenstrup maintained that Captain Madsen's account of the rising of the land was exaggerated.

THE last number of the *Rendiconti della R. Accademia dei Lincei* contains a reference to an Italian precursor of Franklin, the Venetian physician Eusebio Sguario, reputed author of a work on "Electricity, or the Electrical Forces of Bodies," published in 1746. In this work occurs the following passage:—"Still it seems impossible for the violence of a subtle effluvium to acquire such intensity, however increased we may suppose it to be, unless by this means we should succeed in discovering the tremendous velocity of that subtle igneous matter which constitutes lightning. And who will ever venture boldly to deny that lightning is nothing else than a subtle electrical substance impelled to the last degree of its violence? It would certainly be a fatal surprise for that experimenter, who, finding in this way a means of producing artificial lightning, might fall a victim to his curiosity." This was written two years before the appearance of the work on physics by Nollet (Paris, 1748), who has hitherto been supposed to be the first writer who has expressed in clear language the close relation existing between the phenomena of electricity and lightning.

THE British Secretary of Legation in Rio de Janeiro, in a recent report states that for many years, though with varied intensity, a destructive disease has existed in the best zone of territory for coffee in the province of Rio de Janeiro. It has never been so bad as the coffee-leaf disease in Ceylon and Java, but still has done much harm. A scientific Government *employé*, Dr. E. Gölde, in correspondence with Dr. Soltmedel, of Java, has now almost proved that the Brazilian root-disease and the Ceylon leaf-disease have the same origin—namely, a small worm in the root, belonging to the group of Nematoids, similar to the worm in beetroots in Europe.

THE Hydrographical Department of Russia has devoted, since 1837, a good deal of attention to the secular rising of the coasts of the Baltic Sea, and a number of marks have been made on the rocky coasts of the Gulfs of Bothnia and Finland in order to obtain trustworthy data as to the rate of the upheaval of the coasts. Since 1869, observations have been carried on in a systematic way for measuring the changes in the level of the Baltic at several of the above-mentioned marks, and the results of the observations are now summed up by Colonel Mikhailoff in the *Izvestia* of the Russian Geographical Society (vol. xxiv. 3). Taking only those stations at which the secular change could be determined for a number of years varying from thirty-one to thirty-nine years (1839-78), the rise of the coast in a century would appear to be as follows: Aspö, 20·3 inches; Lehtö, 11·5 inches; Island of Kotkö, 26·7; Sveaborg, 22·8 and 25·1; Hangöudd, 33·7; Island of Skotland, 12·5; Island of Jussari, 31·6; Tverminö, 36·2; Island of Gloskär at Redhamn, 12·2. It thus appears that the figure of about three feet in a century, which was deduced from former observations, cannot be very far from the truth. As to local anomalies, they remain still unexplained.

The additions to the Zoological Society's Gardens during the past week include two Yellow-fronted Tanagers (*Euphonia flavifrons*) from Dominica, presented by Mrs. Herbert; two Manx Shearwaters (*Puffinus anglorum*) from the Scilly Islands, presented by Mr. F. Hensman; an Ocelot (*Felis pardalis*) from South America, deposited; four Black-tailed Godwits (*Limosa ægocephala*), European, purchased; two Indian Muntjacs (*Cervulus muntjac* ♂ ♀) from India, received in exchange; a Persian Gazelle (*Gazella subgutterosa* ♀), two Bennett's Wallabys (*Halmaturus bennetti* ♀ ♀), a Hog Deer (*Cervus porcinus* ♂), a Collared Fruit Bat (*Cynonycteris collaris*), two Grey Wagtails (*Motacilla melanope*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

Comet 1888 *e* (Barnard, September 2).—The following ephemeris for Berlin midnight for this object is in continuation of that given in Nature, vol. xxxix. p. 616:—

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
June 1	22 54 22	2 39·9 N.	0·3730	0·3441	2·1
5	22 47 38	2 40·5	0·3786	0·3317	2·1
9	22 40 4	2 38·1	0·3842	0·3193	2·2
13	22 31 38	2 32·5	0·3898	0·3070	2·3
17	22 22 16	2 23·6	0·3954	0·2952	2·4
21	22 11 57	2 10·7 N.	0·4010	0·2839	2·4

The brightness at discovery is taken as unity.

The Motion of Stars in the Line of Sight.—Prof. H. C. Vogel, noting the difficulty which has been experienced at the Greenwich and Rugby Observatories in making eye-observations of the displacement of the lines in stellar spectra due to the approach or recession of the stars, has endeavoured to solve the problem by means of photography, and has met with very considerable success. The atmospheric tremors, which are so baffling and often misleading to direct eye-observation, counteract each other and produce little or no effect on the photograph; and the feebleness of the light of a star when spread out into a long spectrum is overcome by a lengthened exposure. Prof. Vogel gives the following results (in German miles per second) for five stars, of which four have been observed at Greenwich:—

Star.	Vogel.	Greenwich.
Capella	+3·5	+4·8
Aldebaran	+6·5	+6·8
Polaris	−3·5	not observed
α Persei	−1·5	−4·8
Procyon	−1·5	−0·8

The Greenwich observations for 1888, nearly contemporaneous therefore with the Potsdam observations, give the motion of Procyon as −0·8. The agreement of the individual photographs is very gratifying, and is much closer than that of the eye-measures made on different nights.

The Latitude of Detroit.—A determination of the latitude of the Detroit Observatory has recently been made by Dr. Ludovic Estes.[1] The zenith telescope was employed, and the results were discussed by the method of least squares. The value arrived at after all corrections is 42° 16′ 48″·66 ± 0″·051. An interesting point in connection with the observations is that smaller values were obtained from low stars, which seems "to indicate that northern stars are refracted less than southern, for the same zenith distance; and that, therefore, the layers of the atmosphere, instead of being parallel to the surface of the earth, are depressed more rapidly toward the north" (p. 54).

The Minor Planet Victoria.—A programme has been prepared by Dr. Gill, of the Royal Observatory, Cape of Good Hope, for observations of the minor planet Victoria at its opposition in 1889; the opposition in right ascension occurring on July 16, and the primary object of these observations being to determine the parallax of the sun from heliometric measures. A list of comparison stars is given, and is so arranged that when the planet is situated at the greatest zenith distance where good observations may be made, one comparison star may be below and another above it, the measurement by the heliometer of the difference of two nearly equal and opposite distances giving the most accurate result obtainable.

[1] Ann Arbor, Mich.: The Register Printing and Publishing Company, 1888.

Victoria has a zenith distance of 62° at an hour-angle of 4h. for the Cape, 2h. for European Observatories, and 3h. for Newhaven. A list is given of the limits of hour-angle during which observations of the planet may be made from June 10 to August 29.

The corrected ephemeris of the planet has been computed, and it is hoped that co-operating meridian Observatories will determine the places of the thirty-seven comparison stars with the meridian circle, and at the same time procure as many meridian observations of the planet as possible. Provided that means exist for determining the distortion of the photographic film, and the optical distortion of the field, photographs taken in both hemispheres showing the planet lengthened out so as to form a straight line, whilst neighbouring stars are well defined, are available for the determination of parallax. Dates are also given when photographic observations of Victoria may be advantageously combined with heliometer observations.

Meridian Observations of Iris.—A similar programme to the above was issued by Dr. Gill, in September 1888, for observations of the minor planet Iris; and Mr. Arthur A. Rambaut, assistant astronomer at Dunsink Observatory, has made observations, with the meridian circle, of the places of the planet and the twenty-eight comparison stars given. The measures will be found in *Monthly Notices R.A.S.*, March 1889, and extend from September 7, 1888, to January 10, 1889. Between these dates twenty-six observations of Iris were made, and its apparent right ascension and declination found. During the progress of the work two comparison stars were added to Dr. Gill's list.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JUNE* 2–8.

(For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on June 2

Sun rises, 3h. 50m.; souths, 11h. 57m. 45·8s.; daily increase of southing, 9·6s.; sets, 20h. 6m.: right asc. on meridian, 4h. 42·3m.; decl. 22° 15′ N. Sidereal Time at Sunset, 12h. 52m.

Moon (at First Quarter on June 6, 20h.) rises, 6h. 42m.; souths, 15h. 2m.; sets, 23h. 17m.: right asc. on meridian, 7h. 46·8m.; decl. 22° 19′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° ′
Mercury	5 4	13 25	21 46	6 9·7	23 56 N.
Venus	2 25	9 28	16 31	2 12·5	11 33 N.
Mars	4 1	12 16	20 31	5 0·6	23 19 N.
Jupiter	21 49*	1 44	5 39	18 26·6	23 6 S.
Saturn	8 52	16 28	0 4*	9 13·2	17 17 N.
Uranus	14 52	20 22	1 52*	13 7·7	6 31 S.
Neptune	3 31	11 18	19 5	4 2·6	19 5 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

June.	h.	
4	8	Saturn in conjunction with and 1° 47′ south of the Moon.
6	—	Venus at period of greatest morning brilliancy.
6	20	Mercury stationary.

Saturn, June 2.—Outer major axis of outer ring = 39″·1: outer minor axis of outer ring = 10″·6: southern surface visible.

Meteor-Showers.

	R.A. °	Decl. °	
Near β Coronæ	228	30 N.	June 2.
,, β Ophiuchi	262	5 N.	Rather slow.
,, α Cephei	317	61 N.	Swift; streaks.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	June 4,	23 49	*m*
S Cancri	8 37·6	19 26 N.	„ 5,	3 18	*m*
R Virginis	12 32·9	7 36 N.	„ 7,		*M*
δ Libræ	14 55·1	8 5 S.	„ 3,	22 7	*m*
R Ursæ Minoris	16 31·5	72 30 N.	„ 3,		*M*
U Ophiuchi	17 10·9	1 20 N.	„ 6,	3 14	*m*
			„ 6,	23 22	*m*
X Sagittarii	17 40·6	27 47 S.	„ 7,	0 0	*m*
U Sagittarii	18 25·6	19 12 S.	„ 2,	2 0	*m*
			„ 5,	1 0	*M*
R Lyræ	18 52·0	43 48 N.	„ 5,		*M*
R Sagittæ	20 9·0	16 23 N.	„ 7,		*m*
U Capricorni	20 42·0	15 12 S.	„ 7,		*M*
W Cygni	21 31·9	44 53 N.	„ 8,		*M*

M signifies maximum; *m* minimum.

GEOGRAPHICAL NOTES.

AT the anniversary meeting of the Royal Geographical Society on Monday, the medals and other honours already announced in NATURE were awarded. Dr. Radde, of Tiflis, appeared in person to receive his medal, which he acknowledged briefly and appreciatively. The address of the President, General Strachey, was of more than usual interest. After referring to the geographical events of the year, he took up the subject of Central Africa, its future exploration, and its subjection to the commercial and civilizing influence of Europe. General Strachey reviewed the results of European contact with the various other parts of the world, savage and semi-civilized. "There is no room to doubt," he said, "that the occupation of the earth by man in the many various modes presented to us has been determined mainly by the physical conditions of the surface, the distribution of land and sea, and the nature of the climate, operating in conjunction with the particular inherited capacities of the several branches of the human race, which have themselves been largely determined by these same physical conditions. The diffusion of races, and their more or less permanent occupation of various parts of the earth, have necessarily been regulated by their relative powers of adapting themselves to, and taking advantage of, the facilities for existence offered by the regions they occupied, and of resisting adverse pressure of all sorts brought to bear upon them from without. Among the best safeguards against that form of pressure which consists of the intrusion of other races, have ever been isolation by the ocean, or by high mountains, great land distances, forests and deserts; and hence it has been that the interiors of the great continents have for the most part been last explored, and their inhabitants least disturbed. As the first of these defences was weakened by the development of the art of navigation, the progressive races of Europe began to seek for fresh scope for their activities in many distant regions, thus for the first time rendered accessible to them. From very small beginnings within the Mediterranean, which for several centuries gained strength only by slow degrees, at length burst forth some 400 years ago the stream of conquest and commercial adventure which has in our time been carried across every part of the ocean; and has beaten on all its shores, throwing open an infinitude of lines of attack for the inroads of European progress upon regions previously resting in various conditions of relatively primitive stagnation." General Strachey then, in a highly suggestive manner, reviewed the methods and results of European conquest or European civilization in North, Central, and South America, Australasia, India, China, North Africa and South Africa, and, coming finally to Central Africa, he pointed out that the conditions there were peculiar and required peculiar treatment. "The vast area of tropical Africa," he said, "its climate, often so hostile to Europeans, and the numbers and character of the population, combined with the peculiar difficulties attending all transport in the interior, have retarded the progress of geographical discovery, and obstructed that intercommunication between neighbouring districts which supplies the natural machinery by which the progress of the less advanced races is carried forward. It is impossible to suppose that the impression to be made on these countries by the mere handful of men of northern race who are now scattered along its coasts or at a few points in its interior, can be anything but extremely slow, and it is hardly less certain that under the wholly different conditions that Central Africa presents from those of any other country hitherto brought within the operation of the process of civilization, the form which that process will take, and its results, will be very different from anything that past experience can suggest. The possibility of any colonization by direct immigration on such a scale as to produce effects in any way analogous to those obtained in North America or Australia is obviously excluded; the condition of the people over the greater part of the continent renders it equally impossible to look forward to a time when systems of administration at all approaching that of India could be established; and amalgamation between European settlers and the indigenous races appears no less out of the question. The operation of bringing a population such as that of Central Africa under the restraints of civilization will necessarily be a long and no doubt in some respects a painful one, for assuredly the conflict with slavery, cannibalism, and massacre cannot be carried to a successful issue by gentle means alone. The dangers that attend precipitation, with consequent reaction, have been already exemplified too plainly, and by the sacrifice of too many noble lives; and in circumstances such as those that here have to be dealt with, toleration of unavoidable evil at the outset may well afford the best and most certain means of introducing permanent improvement. Nor can I see any reason to question the conclusion that the best method of entering on this gigantic task is that which the general sense of Europe has practically resolved to adopt—namely, to form commercial associations intrusted with the exercise of reasonable administrative authority within the several areas assigned to them, hoping that thus the African population may by degrees be taught that the path to social and material comfort and well-being lies through well ordered industry and peaceful occupations; in imparting which lessons the earnest co-operation of the many purely philanthropic missions already established among these people may be most confidently counted on."

BEACON LIGHTS AND FOG SIGNALS.[1]

II.

IN 1876, Mr. Julius Pintsch, of Berlin, patented in this country his system of illuminating buoys or other floating bodies by compressed oil gas, and in 1878 one of these buoys was experimentally tried at sea with success by the Trinity House. The system is similar to that previously adopted by Mr. Pintsch with great success in the lighting of railway carriages, but with the addition for buoys of a specially constructed lantern, containing a small cylindrical lens for fixed light. Through the kindness of the Pintsch's Lighting Company, we have here one of these apparatus, producing an intensity in the beam of about twenty candle units. With the charge of gas contained in the buoy, the light is shown continuously, night and day, from two to four months, according to the dimensions of the buoy, without refilling or requiring any other attention except occasional cleaning of the lens and the glazing of the lantern. In 1883, Mr. William B. Rickman patented a very ingenious addition to this apparatus for producing occulting or flashing light. The apparatus is automatically worked by the issuing compressed gas on its way from the buoy to the burner. After passing the regulator where the pressure of the gas is reduced for burning, it enters a cylindrical chamber covered with a diaphragm of very flexible specially prepared leather, this diaphragm, on being slightly raised by the in-flowing gas, communicates motion to a lever, which, assisted by a spiral spring, closes the inlet pipe, and opens at the same time the passage to the burner. As the gas passes on and is consumed at the burner, the diaphragm by its own weight, assisted by the spring, sinks, and touching the lever, closes the outlet aperture to the burner, and at the same moment opens the inlet of the gas from the buoy for another charge. Thus the light is extinguished while the gas is entering the chamber, and until the latter is refilled, when the passage from the buoy is again closed by the rising of the diaphragm. A small pilot jet is constantly burning to insure the re-ignition of the gas when re-admitted to the burner. It is evident that several characteristic distinctions of light may be obtained by modifications of this ingenious apparatus. About 150 buoys lighted on the Pintsch system are already rendering valuable

[1] Friday evening discourse delivered at the Royal Institution by Sir James N. Douglass, F.R.S., on March 15. Continued from p. 91.

service to mariners in various parts of the world. For the more important stations at sea where light-vessels are now employed the system is considered to be yet wanting in that trustworthiness which should be the leading characteristic of all coast lighting. Very important experiments have lately been made by the Lighthouse Board of the United States, at their General Depot at Tompkinsville, New York, with buoys lighted electrically by glow lamps, operated through submarine conductors from the shore. These experiments have proved so successful that an installation for marking the Gedney's Channel entrance of Lower Bay, New York Harbour, with six buoys and 100-candle glow lamps, was lighted on November 7 last. Gas buoys were considered inapplicable for this special case, owing to their form and size rendering them liable to break adrift, particularly when struck by floating ice or passing vessels. The buoy adopted for the service consists of a spar 46 feet long, having its lower end shackled direct to a heavy iron sinker, resting on the bottom. At the upper end the buoy is fitted with an iron cage inclosing a heavy glass jar, in which is placed the glow lamp of 100 candle units intensity. The cable is secured by wire staples in a deep groove cut in the buoy and covered by a strip of wood. For a distance of several feet at the lower end of the buoy the cable is closely served with iron wire, over which is wound spun yarn to prevent injury from chafing on the shackle and sinker. The central station on shore, with steam-engines and dynamos in duplicate, is on Sandy Hook, at a distance from the extreme buoys of about 3 nautical miles. The installation is reported to be working continuously and successfully. For auxiliary or port lights on shore where no collisions can occur, the Pintsch gas system is found to be very perfect. At Broadness, on the Thames, near Gravesend, the Trinity House erected in 1885, an automatic lighthouse illuminated on Pintsch's system, as shown by the diagram. This small lighthouse shows a single flashing light at periods of ten seconds, the flashes having an intensity of 500 candle units. The flashes and eclipses are produced with perfect regularity by special clockwork, which also turns on the gas supply to the burner at sunset and off again at sunrise. It is also arranged for periodic adjustment for the lengthening and shortening of the nights throughout the year. This automatic light is in the charge of a boatman, who visits it once a week, when he cleans and adjusts the apparatus, and cleans the glazing of the lantern. An automatic lighthouse similar to that at Broadness has been lately installed at Sunderland by the River Wear Commissioners, on a pier which is inaccessible during stormy weather. In 1881–82 several beacons automatically lighted by petroleum spirit, on the system of Herr Lindberg and Herr Lyth, of Stockholm, were established by the Swedish lighthouse authorities, and are reported to be working efficiently. In 1885 a beacon or automatic lighthouse on this system was installed by the Trinity House on the Thames, near Gravesend, and has been found to work efficiently. The light is occulting at periods of about two seconds; the occultations are produced by an opaque screen, rotated around the light by the ascending currents of heated air from the lamp acting on a horizontal fan. As there is no governor to the apparatus, the periods of the occultations are subject to slight errors compared with those of the gas light controlled by clockwork. In 1844 an iron beacon lighted by a glow lamp and the current from a secondary battery was erected on a tidal rock near Cadiz. Contact is made and broken by a small clock, which runs for twenty-eight days, and causes the light to flash for five seconds at periods of half a minute. The clock is also arranged for eclipsing the light between sunrise and sunset. The apparatus is the invention of Don Isaas Lavaden, of Cadiz, to whom I am indebted for kindly showing me the light in action when on a visit to Cadiz in 1885. There is every probability that automatic beacons lighted either by electricity, gas, or petroleum spirit, will in consequence of their economy in maintenance be extensively adopted in the future.

Coal and wood fires, the flames produced by the combustion of tallow, nearly all the animal, vegetable, and mineral oils, coal and oil gas, and the lime-light, have been employed from time to time in lighthouse illumination, and last but not least, the electric light. None of these illuminants have received such universal application in all positions both ashore and afloat as mineral oil at the present moment, and justly so, when we consider its efficiency and economy for the purpose. So recently as 1822, the last beacon coal fire in this country was replaced by a catoptric oil light, at Saint Bees Lighthouse, on the coast of Cumberland. We have here diagrams of two of these coal fire beacons, one of them designed and erected by Smeaton in 1767 on his lighthouse at the Spurn Point, on the east side of the entrance to the Humber. So late as 1845, sperm oil was entirely used in the lighthouses and light-vessels of the Trinity House; but, shortly afterwards, colza was adopted with the same efficiency, and with a saving in annual cost of about 44 per cent. In 1861, experiments were made by the Trinity House for determining the relative efficiency and economy of colza and mineral oil for lighthouse illumination; but owing to the imperfect refinement of the best samples of the latter then procurable in the market, together with its high price, the result of the investigation was not so satisfactory as to justify a change from colza. In 1869, the price of mineral oil of good illuminating quality, and safe flashing-point, was found to be procurable at about half the price of colza, when the Trinity House determined to make a further series of experiments, and by these it was ascertained that, with a few simple modifications of the argand burners then in use, they were rendered very efficient for the purpose; it was also found that these burners were thus considerably improved for the combustion of colza. A change from colza to mineral oil was then commenced, and mineral oil is now generally adopted in the lighthouses and light-vessels of the Trinity House service; and with even greater economy than was at first anticipated, the price of this illuminant being now rather less than one-third that of colza. The most powerful oil burner then in use was one of four concentric wicks, the joint production of Arago and Fresnel, and adopted by the French lighthouse authorities about the year 1825, in conjunction with the then new dioptric system of optical apparatus of Fresnel. The standard intensity of the combined flames of this burner, one of which we have here, was 260 candle units. A further development was made during the experiments of the Trinity House in 1871, by increasing the number of wicks from four to six, which more than doubled the intensity of the light, while effecting a condensation of the luminary per unit of focal area, or, in other words, improved the optical efficiency 70 per cent. We have here also one of these burners.

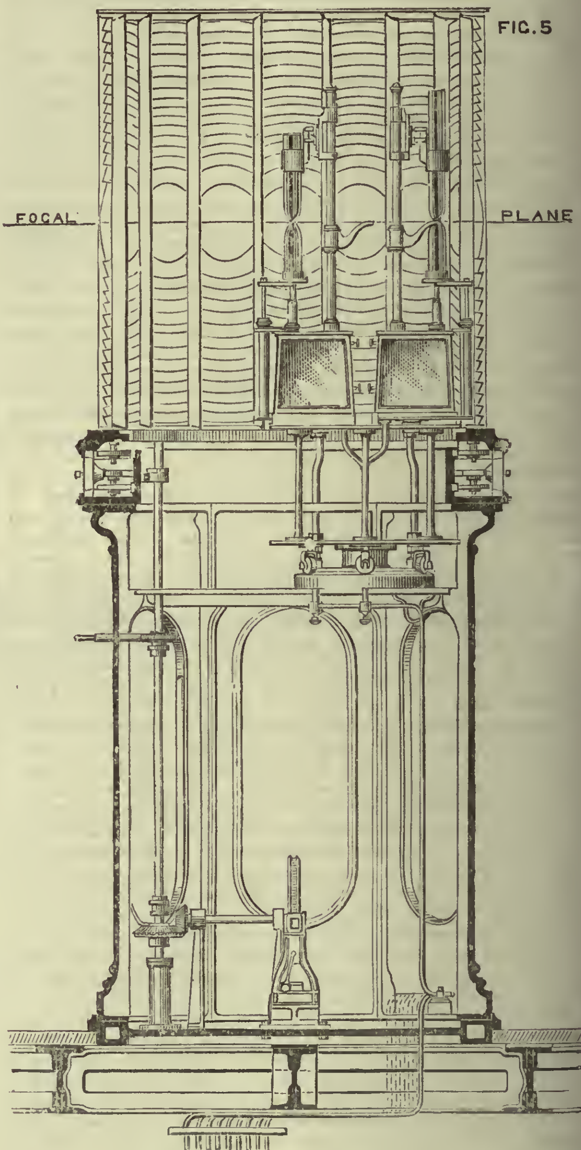
I have since devised an argand burner for the combustion of all illuminating gases and oils, whereby still further condensation of the flames, together with greater intensity and economy of combustion, is obtained, and the glass chimney is protected from breakage. These improvements are effected by a special arrangement and distribution of the air currents through the rings of flame, and between them and the glass chimney. We are thus enabled on this system to increase the dimensions of lighthouse burners, for gas and oil, for ten or more rings of flame. With ten rings, we obtain an aggregate intensity, when burning cannel gas and good mineral oil, of considerably over 2000 candle units, while the improved efficiency of the luminary for optical cendensation of the radiant light per unit of focal area, as compared with the luminary of the Fresnel four-wick oil burner, has been in each case increased 109 per cent. With reference to the perfect combustion of these highly condensed flames, I may state that the efficiency for gas is exactly double that of the London standard argand burner, viz. when consuming gas of the London standard of sixteen candles, the light produced is at the rate of 6·4 instead of 3·2 candles per cubic foot. In addition to a single ring gas burner of this type we have two burners of the ten rings of flames, and models of their flames, one for gas and the other for mineral oil. These burners are all of the Trinity House new pattern, both gas and oil, and they are of the same general arrangement for combustion, except that the oil burner is provided with cotton wicks. Both produce flames of nearly the same form, dimensions, intensity, and colour.

The first application of coal gas to lighthouse illumination was made at the Troon Lighthouse, Ayrshire, in 1827; and in 1847 it was adopted at the Hartlepool Lighthouse, Durham, where for the first time it was employed in combination with dioptric apparatus of the first order of Fresnel. The slow progress made with coal gas in lighthouses, except for harbour lights, where the gas could be obtained in their vicinity, as at Hartlepool, was chiefly due to the great cost incurred in the manufacture of the small quantity required, and at the usual isolated positions occupied by coast lighthouses, involving extra cost both for labour, and for the extra transport of the coal. In 1865, the attention of lighthouse authorities was directed to gas, as an illuminant for lighthouses, by Mr. John R. Wigham, of Dublin, whose system was tried in that year, at the Howth Bailey Lighthouse, Dublin Bay. The gas burner of Mr. Wigham, one of which we have here, consists of seven concentric rings, of single flat-flame burners, amounting in the aggregate to 108. The burner is used without a glass chimney, and thus there is no appreciable condensation of the group of flames, for their employment at the focus of optical apparatus, and the relative aggregate intensity of the seven rings of flat flames per unit of focal area, as compared with the four concentric flames of the old four-wick oil burner of Fresnel, is only 2½ per cent. higher than the latter. The burner has five powers, for varying states of the atmosphere. For the minimum intensity, 28 jets are employed; and with the whole 108 jets there is a maximum aggregate intensity of the flames with cannel gas of about 2500 candle units. Several lighthouses on the coast of Ireland have been illuminated with gas, on the system of Mr. Wigham, and two at Haisborough, on the coast of Norfolk. In 1878, Mr. Wigham installed at the Galley Head Lighthouse, County Cork, his system of superposed gas flames, and group-flashing light, which consisted of four of his large gas burners vertically superposed. In conjunction with these were four tiers of first order annular lenses, eight in each tier. By successive lowering and raising of the gas flames at the focus of each tier of lenses, he produced his group-flashing distinction. This light shows, at periods of one minute, instead of the usual single flash from each lens, or vertical group of lenses, a group of short flashes, varying in number between six and seven. The unavoidable uncertainty with this system in the number of flashes contained in each group is unfortunate for the mariner, who, with the continued increase in the number of coast lights, requires the utmost precision in the distinctive character adopted for each.

In 1857, an experimental trial of the first magneto-electric machine of Holmes, for the practical application of the electric light, was made by the Trinity House at Blackwall, under the direction and to the great delight of their scientific adviser, Faraday; and after a series of experiments the satisfactory report of Faraday encouraged the Trinity House to order a practical trial of a pair of the Holmes machines. The trial was made at the South Foreland High Lighthouse by Faraday and Holmes on December 8, 1858, when electricity was found to be a formidable rival to oil and gas for lighthouse illumination, and this position it maintains to the present day. The trials of this arc light were made at the focus of the first order dioptric apparatus for oil light, which was very imperfect for the purpose, but they were sufficiently encouraging to lead the Trinity House, under the advice of Faraday, to proceed further with the electric light for lighthouses. Faraday thus wrote in his report to the Trinity House:—"I beg to state that, in my opinion, Prof. Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other that I have yet seen so applied, and in principle may be accumulated to any degree; its regularity in the lantern is great, its management easy, and its care, there may be confided to attentive keepers of the ordinary intellect and knowledge."

These truly prophetic words of Faraday's have been entirely realized. Electricity still stands foremost in the illumination of our coasts, and appears destined to be one of the greatest blessings ever conferred on humanity, and more especially on "those who go down to the sea in ships." On February 1, 1862, Holmes's machines and apparatus for electric light were installed at Dungeness Lighthouse; and in 1863, the French lighthouse authorities followed, by an installation of the Alliance Company's magneto-electric machines and apparatus for fixed lights at each of the two lighthouses at Cape La Hève. We have here the first dioptric apparatus designed and manufactured by Messrs. Chance Brothers and Co., of Birmingham, for the electric fixed light at Dungeness. We have also one of the Holmes lamps employed there. The lamp used at the previous experiments was devised by M. Duboscq, of Paris. This lamp of Holmes's is similar to those of Duboscq and Serrin, excepting that the upper and lower carbons and holders are balanced and regulated through pulleys and small catgut cords, instead of by rack and pinions. The carbons are ¼ inch square, and the mean intensity of the light in the arc was 670 candle units nearly. We have here samples of the carbons employed from time to time in the development of the electric light in lighthouses; we have also a Bergot lamp fitted with the fluted form of carbons I have recently devised. They are of the dimensions now in use in the optical apparatus at the St. Catharine's Lighthouse, and are giving a mean intensity in the arc of 40,000 candle units (Fig. 5). Cylindrical compressed carbons were soon manufactured for the electric light, and were found to be more homogeneous in quality, and the flickering of the light less, than with the original square carbons, which were simply sawn from the residual carbon of gas retorts; but there was still the objectionable crater at the points, whether direct or alternating currents were employed, involving flickering from the incessant shifting of position at the points. A considerable loss of radiant light was also involved, particularly when condensing it optically. The flickering was somewhat reduced by an improvement of Messrs. Siemens', in providing the carbons with a graphite core, but with the increasing powers of currents,

FIG. 5



and in the necessary dimensions of carbons, the results were far from satisfactory. With the fluted form of carbon shown on the diagram, the formation of the crater is prevented, and the arc is held centrally at the points of the carbons; there is thus, in addition to comparatively steady light, nearly uniform radiation in azimuth, and over a greater vertical angle for optical condensation. It now appears to me, after some practical experience with this form of carbon, that it is impossible to determine a practical limit to the dimensions of carbons that may be efficiently employed. With carbons of the actual size shown on the diagram, an intensity of about a million candle units should be produced in the arc, and about 150 millions of candle units in the condensed flashes from the optical apparatus of the dimensions now employed for oil and gas flames in lighthouses. Such an intensity is about four hundred times that possible at the focus of such apparatus with a flame luminary. Such results as these were probably in the mind of Faraday when he reported that "in principle this light may be accumulated to any degree." Flashes of the great intensity here referred to could only be employed in atmosphere impaired for the transmission of light. In clear weather they would be found to be far too dazzling to the eyes of the mariner, when an intensity of about 50,000 candle units is found to be sufficient for his guidance, and in thick fog no possible intensity can be of practical value for navigation. There are, however, various gradations of impaired atmosphere between clear weather and thick fog, in which the highest available intensity is doubtless desirable at many important landfall stations for obtaining the greatest possible range of visibility. On the other hand, at the majority of stations in narrow waters, the maximum intensity now obtained with flame light is found to be more generally efficient for navigation than higher intensities.

In 1881, the question of the relative merits of the three lighthouse illuminants—electricity, gas, and mineral oil—was receiving the attention of the lighthouse authorities of this country, which resulted in the Trinity House accepting the responsibility of carrying out an investigation at the South Foreland, of universal importance to the mariner. In the photometrical and electrical portions of this work, the Trinity House were aided by the labours of Prof. Harold Dixon, F.R.S., and Prof. W. Grylls Adams, F.R.S., which contributed very largely to the success of the investigation. The experiments were carried on during a period of over twelve months, and a vast amount of very valuable evidence was collected from numerous observers, trained and untrained, scientific and practical. The Report of the Committee was presented to both Houses of Parliament, by command of Her Majesty, in 1885. The final conclusions of the Committee are given in the following words: "That, for the ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

I have already referred to the necessity, with the present development of maritime commerce, that every beacon light maintain a clearly distinctive character. When the optically unaided flames of coal fires were the illuminants of our lighthouses, distinctive characters, owing to the small number of lights then employed, were of little importance, and the only distinctions then possible were the costly ones of single, double, or triple lighthouses at one station; but, with the enormous increase that has since occurred in the floating commerce of the world, and with the necessary laws now in operation, requiring all vessels to carry lights, trustworthy individuality in coast beacon lights has become a positive necessity. Until very recently, the distinctive characters consisted of the following, viz. fixed white, fixed red, revolving white, revolving red, and revolving white and red alternately. The revolving lights showed a flash at periods of ten seconds, twenty seconds, thirty seconds, one minute, two minutes, three minutes, and four minutes. There were also intermittent or occulting lights, having an eclipse at periods of half a minute, one minute, or two minutes. It is now generally considered that fixed lights are no longer trustworthy coast signals, owing to their liability to confusion with other lights, both ashore and afloat. It is also considered that, in these days of high speed vessels, the period of the character of a coast light should not, if possible, exceed half a minute. The revolving or flashing class of lights are probably the most valuable, on account of their superior intensity as compared with the fixed or occulting class, the light during the intervals of eclipse being condensed into each succeeding flash, by the revolving lenses or reflectors, and thus, with the same expenditure of the illuminant, an intensity is obtained in the flashes of five to eight times that of the fixed or occulting class. Where local dangers are required to be guarded by coloured sectors of danger light with well defined limits, this can only be accomplished with the fixed or occulting class of lights. We will illustrate this with the model before us. We will also show the clear difference of character, not generally realized, between flashing and occulting lights. A system of occulting lights for lighthouses was proposed by the late Charles Babbage, F.R.S., in 1851, but as it excluded the flashing or most powerful of the existing lights, it did not receive much favour from lighthouse authorities. In 1872, distinctive characters for coast lights was the subject of a paper by Sir William Thomson, F.R.S., at the Brighton meeting of the British Association for the Advancement of Science, when he directed attention to the extreme importance of ready identification of lights at sea, and proposed the use of quick-flashing lights, their flashes being of longer or shorter duration; the short and long flashes representing the dot and dash of the Morse alphabet as used in telegraphy. It was found, however, that the number of symbols in our alphabetical code would not be sufficient, on a thickly lighted coast, to insure individuality, and render each distinction perfectly trustworthy. Further, that very rapid repetition of each symbol is not required by the mariner, and would involve loss of accumulative power in the flashes, besides incurring unnecessary wear and tear in rotating heavy optical apparatus. Yet much is to be done in the direction of simple distinction. At the Montreal meeting of the British Association, in 1884, I submitted a paper on "Improvements in Coast Signals," in which were suggested, two alphabetical codes of flashing lights, and one of occulting, all having the same period of the symbol, viz. half a minute. In one of the codes of flashing lights, long and short flashes were proposed, as previously by Sir William Thomson; and in the other there were proposed white and red flashes. In the occulting series, long and short eclipses were proposed to be substituted for the long and short, or white and red, flashes, of the flashing codes. The system has the advantage of application to all existing lighthouse apparatus, and many lights have been altered to selected symbols of each of these series.

Little was ever accomplished in the way of warning or guidance to the mariner, during fog, until about the middle of this century. Previously, a few bells had been established at lighthouses in this country and abroad, and gongs of Chinese manufacture had been in general use on board our light-vessels, but both instruments are now acknowledged to be wanting in the efficiency now demanded in fog, to meet the requirements of navigation. The first important improvement in fog signals for the service of mariners was made by the late Mr. Daboll in 1851, who submitted to the United States Lighthouse Board, in that year, a powerful trumpet, sounded by air compressed by horse-power. The apparatus was installed at Beaver Tail Point, Rhode Island, and the favourable results obtained with it stimulated Mr. Daboll, under the encouragement of the United States lighthouse authorities, to the further development of the apparatus; and ultimately he employed Ericsson's caloric engine as the motive power, with automatic gearing for regulating the blasts. In 1854, some experiments on different means of producing sounds for coast signals were made by the engineers of the French Lighthouse Department, and in 1861–62 MM. Le Gros and Saint-Ange Allard, of the Corps des Ponts et Chaussées, conducted a series of experiments upon the sound of bells, and the various methods of striking them. In 1862, Mr. Daboll submitted his improved fog trumpet apparatus, of about three horse-power in the blasts, to the Trinity House, who, under the advice of Faraday, made experimental trials with it in London, and afterwards gave it a practical trial at the Dungeness Lighthouse, where experiments were made with it, against bells, guns, and a reed fog-horn of Prof. Holmes, whose services have been already referred to in connection with the first practical application of the electric light. This fog-horn of Holmes was sounded by steam, direct from one of the boilers employed at the station for his electric light. The results of these experiments were in favour of Daboll's trumpet; and in 1869, one of these instruments was installed on board the *Newarp* light-vessel. In the same year, Holmes having effected further improvements with his steam horn, his apparatus was fitted on board two light-vessels, and sent out to the coast of China, where they were found to give great satisfaction, as compared with gong signals. In 1863, a Committee of the British Association for the Advancement of Science memorialized the President of the Board of Trade, with the view of inducing him to institute a series of experiments upon fog signals. The memorial, after briefly setting forth a statement of the nature and importance of the subject, described what was then known respecting it, and several suggestions were made relative to the nature of the experiments recommended. The proposal does not appear to have been favourably entertained by the authorities to whom it was referred, and the experiments were not carried out. In 1864, a series of experiments was undertaken, by a commission appointed by the Lighthouse Board of the United States, to determine the relative powers of various fog signals which were submitted to the notice of the Board. In 1872, a Committee of the Trinity House, with the object of ascertaining the actual efficiency of various fog signals then in operation on the North American continent, visited the United States and Canada, where they found in service, Daboll's trumpets, steam whistles, and siren apparatus, sounded by steam and compressed air; these latter apparatus were devised by Mr. Felix Brown, of Progress Works, New York; and from the report of the Trinity House Committee, it does not appear that they were greatly impressed with this instrument, but probably they had not an opportunity of testing its real merits as compared with other signals. The late Prof. Henry, of the United States Lighthouse Board, entertained a very high opinion of the siren; and on his advice, and the urgent recommendation of Prof. Tyndall, one of these instruments was sent to England, and included in the fog signal experiments at the South Foreland in 1873–74. This investigation was carried out by the Trinity House, with the view of obtaining definite knowledge as to the relative merits of various sound-producing instruments then in use, and also of ascertaining how the propagation of sound is affected by meteorological phenomena. Prof. Tyndall, as scientific adviser of the Trinity House, conducted the investigation, aided by a Committee of the Trinity House, and their engineer. These experiments were extended over a lengthened period, in all conditions of weather, and the well-known scientific and practical results obtained, together with the ascertained relative merits of sound-producing instruments for the service of the mariner, have proved to be of the highest scientific interest and practical importance. The investigation at the South Foreland was followed up by the Trinity House with further explosive fog signal experiments, in which they were assisted by the authorities at Woolwich Arsenal with guns of various forms, weight of charges, and descriptions of gunpowder. The powders tested were (1) fine grain, (2) larger grain, (3) rifle large grain, and (4) pebble. The result placed the sound-producing powers of these powders exactly in the order above stated; the fine grain, or most rapidly burning powder, gave indisputably the loudest sound, while the report of the slowly burning pebble powder was weakest of all. Here again the greater value of increased rapidity of combustion in producing sound was demonstrated. It was found that charges of gun-cotton yielded reports louder at all ranges than equal charges of the best gunpowder; and further experiments proved that the explosion of half a pound of gun-cotton gave a sound equal in intensity to that produced by three pounds of the best gunpowder. These investigations led the Trinity House to adopt gun-cotton for fog signals at isolated stations on rocks and shoals, as already described, where, from want of space, nothing better than a ball, or gong, it had hitherto been possible to apply. Of all the sound signals now employed for the warning and guidance of mariners during fog, viz. bells, gongs, guns, whistles, reed trumpets, sirens, and sounds produced by the explosion of gun-cotton, the blasts of the siren and explosions of gun-cotton have been found to be the most efficient for coast fog signals; therefore these signals have received the greatest care and attention in their development. The siren doubtless ranks first for stations wherever it can be applied, chiefly on account of its economy in maintenance, and the facility it affords for giving prolonged blasts of any desired intensity or pitch, and thus providing any number of trustworthy distinctive characters that may be required to insure individuality in the signal. Sirens are now employed at many floating and shore stations of the Trinity House; and one, recently installed at Saint Catharine's Lighthouse, Isle of Wight, of the automatic Holmes type, of which we have here a model, absorbs during its blasts not less than 600 horse-power. The audibility of the blasts of this instrument may be considered to be trustworthy at a range of two miles under all conditions of foggy atmosphere, on the sea surface, over which it is intended to be sounded. It is very desirable that for many landfall stations a greater trustworthy range be provided for the mariner, but this can only be afforded by such increased power as would be required for a more powerful electric light installation, to serve the mariner in other gradations of thick atmosphere. A very important improvement and economy has lately been effected in the sirens of the Trinity House, by rendering them always instantaneously available for sounding at their maximum power. This is accomplished by the storage of a sufficient quantity of compressed air, at a pressure considerably above that required for sounding, to work the siren during the time required for raising steam and starting the engine. The signal is thus always in readiness for immediate action day or night, with an expenditure of fuel only incurred during fog, which fortunately on the coast of this country does not exceed an average of 440 hours per annum. The experience yet gained with the most powerful fog signals now in use, although these apparatus far exceed in efficiency for the service of the mariner in fog any light that science can provide, is not yet so satisfactory as we could desire. The best signal is, as I have already stated, occasionally not heard, under certain atmospheric conditions, beyond two miles; while under other conditions, not apparent to the mariner, the signal is distinctly audible at ten miles; therefore there is much to be desired in the development of the means of propagating sound waves, and in rendering them audible to the mariner. In conclusion I would venture to state that, with the best light and sound signals that can be provided, there are conditions of the atmosphere in which the mariner will earnestly look and listen in vain for the desired light or sound signal, and he must still, under such circumstances, exercise caution in availing himself of their guidance, and never neglect the assistance always at hand of his old trusty friend the lead.

PRELIMINARY REPORT OF THE NEWALL TELESCOPE SYNDICATE.[1]

AT the end of the Lent Term the Syndicate met for the first time and drew up a Report to the Council of the Senate, recommending that a Committee of experts should go to Gateshead to view Mr. Newall's telescope and report on its condition and capabilities. A letter of acknowledgment was also sent to Mr. Newall thanking him for his generous offer.

In consequence of their recommendation, Mr. Christie, Astronomer Royal, Mr. Common, F.R.S., and Mr. Graham, First Assistant at our Observatory, went to Gateshead and made a thorough examination of the telescope and of its accessories. They reported to the Syndicate as follows:—

Report on Mr. Newall's 25-inch Refractor.

We the undersigned, being the Committee appointed by the Newall Telescope Syndicate to inquire into and report on the condition and capabilities of the above instrument, beg to submit the following report as the result of an examination made on March 28 and 29. For convenience of reference we have divided the report under three heads:—

1. On the present condition of the telescope and dome.
2. On the necessary work to be done in removing and re-erecting, to put the whole in an efficient state.
3. The capabilities of the instrument when re-erected.

I. On the evening of March 28, the sky being overcast, the quality of the object-glass was tested by artificial stars, formed by the light of a lamp shining through holes in a metal screen, placed at a distance of about 1500 yards. The result of those tests, which it is unnecessary to specify more fully, was sufficient to enable the Committee to come to the conclusion that the object-glass is a remarkably fine one, entirely free from any defect. On the conclusion of those tests about midnight, and as the Committee were about to leave, the sky cleared to a slight extent, and at intervals the telescope was turned upon some stars and upon Saturn. Owing to the state of the atmosphere, the definition was very variable, but the Committee saw enough to confirm them in the opinion they had already formed as to the excellent quality of the object-glass. During these examinations and tests the mounting showed itself to be extremely steady and quite free from vibration. On the morning of the 29th the Committee again met at Ferndene to complete the examination of the instrument and dome by daylight. The telescope is no doubt so well known that it is not necessary to state further than that it is a first-class instrument, mounted on the plan of the elder Cooke, and that it is fully provided with all the necessary appliances to make it an extremely convenient and easily managed instrument.

The condition is such that the necessary cleaning, painting, lacquering, &c., more fully described in the next section, will not be an expensive matter.

The dome and substructure were next inspected. From the brick wall, which rises to a height of about 2 feet, the whole is of iron, the various parts, including the dome, being bolted

[1] Reprinted from the *Cambridge University Reporter*, May 21.

together in such a way as to render taking down and removal a comparatively easy matter. In addition to the circular inclosure supporting the dome, the height of which is about 20 feet, the dome itself being 40 feet diameter, there are two or three rooms and an entrance porch, available as a dark room and computing room. The mechanism for moving the dome and the dome itself are in good order, but in the opinion of the Committee, it would be advisable to go to some expense in providing brackets for the wheels on which the dome runs with horizontal rollers as guides instead of the flanges on the wheels. The observing platform is a first-rate one and will need no alteration. It is suitable for general observational work, or for work where the use of a large spectroscope renders considerable space necessary in any direction.

The shutters of the dome will require some slight repair.

As regards the apparatus with this telescope there are the usual battery of eye-pieces suitable to the telescope; a series of parallel bar, ring, and other fixed micrometers, a very fine parallel wire micrometer, all complete in mahogany boxes; a fine barrel chronograph in glass case, and a good sidereal clock with compensated pendulum. These with sundry apparatus belonging to the telescope complete the outfit.

We had no opportunity of thoroughly testing the clockwork. We consider that it might be advisable to add an electric control and slow-motion gear of the modern pattern in order to render the telescope more efficient in this respect.

II. We have drawn up a specification showing more fully the work required to be done in order to put the telescope simply into an efficient state, but we would recommend that the opportunity be taken to add electric lighting to the circles and micrometer, to provide an electric control to the clock and an electric slow-motion gear. We would further recommend that 12 cast-iron brackets be added to the dome as supports for the wheels, that one or both of the flanges be turned off these wheels, and that horizontal rollers carried by the brackets be added as guides to keep the wheels on the rail. This, we think, would render the turning of the dome much more easy. We would retain the iron circular wall under the dome in preference to a brick or stone wall, as offering more favourable conditions for the telescope. We have added in the appendix our estimate of the cost of this work.

III. When erected and in working order, this telescope will be specially adapted to any work in observational astronomy for which a large aperture is required, and if it is decided to restrict the use of the telescope to micrometric measures of faint satellites, or to the scrutiny of planetary details, no outlay will be required for additional apparatus, beyond an efficient system of lighting the circles and micrometer with small electric lamps. Should it be determined, however, to undertake work in stellar physics, which we understand, from the letter published in NATURE, is the wish of the donor, and which we would strongly recommend as the most useful systematic work to take up, then the necessary spectroscopic outfit, at present wanting, would have to be provided. We estimate the cost of this at about £100. So equipped the telescope would at once be capable of commencing systematic work of first-class importance that would amply repay the cost of keeping such an instrument regularly employed, and in carrying on such systematic work no further outlay in buildings would be required, the computing and dark rooms attached to the dome being sufficient for the work to be done at the telescope. But in our view it would greatly increase the usefulness of this instrument for spectroscopic research if it were placed within easy reach of a physical laboratory where apparatus would be available for experimental investigations in connection with the telescopic observations. As regards the selection of a site we consider it a matter of great importance that the instrument should be located where it would be easy of access to members of the University engaged in making observations with it. It is essential for the effective use of an instrument in a variable climate that the observer should be as near his work as practicable.

W. H. M. CHRISTIE.
A. AINSLIE COMMON.
April 3, 1889. A. GRAHAM.

The previous experience of these gentlemen has also enabled them to give an approximate estimate of the expense of the removal and re erection of the telescope at Cambridge. It appears unnecessary to quote the details of their estimate, but the total sum is given by them as £770.

At the time when Mr. Newall had in contemplation his offer to the University, he was already very ill, and the Syndicate heard with deep regret of his death on the 21st of April. They have reason to believe that he was gratified, before his death, with the prospect that his valuable instrument would probably contribute to the advancement of astronomical science at Cambridge.

Since his death, the executors, with the full approval of his family, have renewed the offer to the University. The Syndicate are of opinion that the University should avail itself of the opportunity of possessing this fine instrument, and they are at present occupied with schemes for its proper maintenance and use.

C. E. SEARLE, *Vice-Chancellor.*
E. J. ROUTH.
J. W. L. GLAISHER.
J. C. ADAMS.
G. D. LIVEING.
G. H. DARWIN.
May 18, 1889. J. J. THOMSON.

SOME PROPERTIES OF THE NUMBER 7.

1. MY attention was recently drawn by a pupil to the following property, which will be best illustrated by working out a particular example:

$$\begin{array}{rrl} \text{Let N} = & 342544\;3 & \\ u_2 = & 34253\;8 & \textit{i.e.}\; u_2 = 342544 - 2 \times 3 \\ u_3 = & 3423\;7 & \phantom{\textit{i.e.}\;} u_3 = 34253 - 2 \times 8 \\ u_4 = & 340\;9 & \phantom{\textit{i.e.}\;} u_4 = 3423 - 2 \times 7 \\ & 32\;2 & \text{and so on:} \\ & 2\;8 & \end{array}$$

if any one of the quantities u_2, u_3, u_4, &c., is divisible by 7, then N is so divisible.[1]

$$\begin{aligned} \text{For, let N} &= 10P_1 + p_0 \\ u_2 &= 10P_2 + q_1 \\ u_3 &= 10P_3 + q_2 \\ u_4 &= 10P_4 + q_3 \\ u_{n-1} &= 10P_{n-1} + q_{n-2} \\ u_n &= 10P_n + q_{n-1} \qquad = 7Q, \text{ by hypothesis.} \\ \text{Now, } 10P_1 &= 10^2P_2 + 10(q_1 + 2p_0) \\ 10^2P_2 &= 10^3P_3 + 10^2(q_2 + 2q_1) \\ 10^2P_3 &= 10^4P_4 + 10^3(q_3 + 2q_2) \\ 10^{n-1}P_{n-1} &= 10^nP_n + 10^{n-1}(q_{n-1} + 2q_{n-2}); \end{aligned}$$

$$\begin{aligned} \therefore N = 10P_1 + p_0 &= 21[p_0 + 10q_1 + \ldots + 10^{n-2}q_{n-2}] \\ &\qquad + 10^{n-1}(10P_n + q_{n-1}) \\ &= 21M + 10^{n-1}(7Q) = 7Q^1. \end{aligned}$$

Or we may proceed thus:—

$u_2 = P_1 - 2p_0$; $\therefore N = 10(u_2 + 2p_0) + p_0 = 10u_2 + 21p_0$; hence, if N is divisible by 7, so also is u_2, and so on.

If for 2 we substitute 1, 3, 4, 5, ... n, then if N is divisible by 11, 31, 41, 51(3, 17), ... $10n + 1$, so also are (the corresponding) u_2, u_3, ... u_n.

In like manner, if we strike off 2, 3, ... n figures, then if N is divisible by (101, 201, ... $10^2n + 1$), (1001, 2001, ... $10^3n + 1$), ... and so on, so are u_2, u_3, ... u_n.

2. This property was suggested by the question, "Prove that a number consisting of six like figures (111111) is divisible by 7."

Let x be the digit, and let it be repeated n times, then if N be of the form $(7p - nx)10^n + (10^{n-1} + 10^{n-2} + \ldots + 10 + 1)x$, *i.e.* such a number as 5733, in which we have $57 + 2 \times 3$ = multiple of 7, it will be divisible by 7, if $-n \cdot 10^n + (10^n - 1)/9$ is, *i.e.* if $(9n - 1)10^n + 1$ is, *i.e.* if $(2n - 1)10^n + 1$ is, *i.e.* if $(k =) (2n - 1) 3^n + 1$ is.

Omitting the case of six like digits, we write down the following table for an inferior number, the use of which is explained subsequently.

(1)		(2)		(3)		(4)		(5)	
$7p+2 \ldots 2$	1	$7p+5 \ldots 5$	11	$7p+6 \ldots$	111	$7p+4 \ldots$	1111	$7p+1 \ldots$	11111
$7p+4 \ldots 4$	2	$7p+3 \ldots 3$	22	$7p+5 \ldots$	222	$7p+1 \ldots$	2222	$7p+2 \ldots$	22222
$7p+6 \ldots 6$	3	$7p+1 \ldots 1$	33	$7p+4 \ldots$	333	$7p+5 \ldots$	3333	$7p+3 \ldots$	33333
$7p+1 \ldots 1$	4	$7p+6 \ldots 6$	44	$7p+3 \ldots$	444	$7p+2 \ldots$	4444	$7p+4 \ldots$	44444
$7p+3 \ldots 3$	5	$7p+4 \ldots 4$	55	$7p+2 \ldots$	555	$7p+6 \ldots$	5555	$7p+5 \ldots$	55555
$7p+5 \ldots 5$	6	$7p+2 \ldots 2$	66	$7p+1 \ldots$	666	$7p+3 \ldots$	6666	$7p+6 \ldots$	6666

[1] In fact, 21 may be substituted for 7.

That is, third line of (3) say, 67333, 781333, &c. (note $67 = 7 \times 9 + 4$, $781 = 7 \times 111 + 4$), are multiples of 7. We may preface any one of the above series of numbers with, or affix to them, sextets of digits, like or unlike to those of the number we select. I confine my attention to sextets of like figures affixed, as in this way I am able to find what values of n make k a multiple of 7.

The series in (1) is, of course, $n = 1, 7, 13, 19$, and so on: and so for the other sets. The values of n to be taken are:—

for (1), $n = 19, 61, 103, 145, \ldots$

(*i.e.* if we write down 19 3's, we must preface these with a number of the form $7p + 6$.)

(2), $n = 2, 44, 86, 128, \ldots$
(3), $n = 15, 57, 99, 141, \ldots$
(4), $n = 10, 52, 94, 136, \ldots$
(5), $n = 41, 83, 125, 167, \ldots$

University College School. R. TUCKER.

THE BHILS AND THEIR COUNTRY.

IN the current number of the *Asiatic Quarterly Review*, Sir Lepel Griffin has a long and most interesting article on the Bhils, an aboriginal tribe of Central India living in the jungle and rough country around the Vindhya Mountains. Sir Lepel says that for eight years he presided over the province which includes the Bhil country, and he had ample opportunity in that time of studying the habits and language of this interesting people. The people themselves claim that they represent the aboriginal races of India who were forced to retire before the Aryan conquerors. Through their country flows the sacred Nerbudda River with all its Hindu shrines. The Bhils, however, seem to care very little for the Hindu deities; they have been forced by the Hindus, who treat them with profound scorn and contempt, to give a sort of half-hearted acceptance of the chief Hindu deities, but in fact they never worship the gods of their superiors. In one respect, however, they agree with the Hindus, and that is in regarding the Nerbudda with feelings of terror and veneration. From the earliest days of the Aryan conquest of India, the Bhils have been looked on as wild animals, deserving of no protection or kindness. In a few States, such as Barwani and Rajpur, they were so numerous, that their conquerors found it more profitable to tolerate them, keeping them, however, at the same time, in the most abject poverty and subjection. Since the advent of the British Government, the condition of these simple and harmless people has much improved, so that the poor Bhils are gradually becoming less and less savage. Their knowledge of woodcraft and of the habits of birds and beasts makes them invaluable to English officers. Unlike the orthodox Hindu, the Bhil has always eaten the flesh of the cow and the buffalo and other abhorred animals. In fact, he eats every wild animal except the monkey, which is universally worshipped in the form of the forest god Hanumán. The tiger is held in great respect, and the people are very unwilling to kill it, unless it is a man-eater. If a beast has thus become obnoxious, a trial is held with religious rites, and if the animal is found guilty, sentence is passed upon him, he is pursued, killed, and hung up on a tree over the main road as a warning to all evil-doers of his species. It is very curious, and shows the antiquity of this race, that at the coronation of the highest Rajput chiefs, in States where the Bhils live, the sacred mark of kingship is impressed on the forehead of the new chief by the head of the Bhil family to which this hereditary privilege belongs, and the Bhils do not regard him as their king till this ceremony is performed. The Bhils are noted for their endurance, for their capacity of living where others would starve, their indifference to the greatest changes of temperature. Not even to save his life will a Bhil tell a falsehood. Their most solemn oath is by the dog, their most valuable companion in the chase. They are gay and of a light-hearted disposition, and take every opportunity of having a feast and a drinking-bout. Their drink is made from the Mowra, a tree which abounds in Central India, the white flowers of which, when pounded and mixed with grain, form a palatable food, and when distilled by a simple process produce a highly intoxicating spirit. Their priests are not of any particular caste, but the office is an hereditary one. The deities most generally worshipped are the ordinary Vedic deities of water, fire, and the heavens, and each village has its presiding deity, who is a different personage in each village. Like Hindus they burn their dead, except unmarried children of both sexes, who are buried, as also those who die from small-pox. In case of cholera they also bury the dead, believing that the smoke from the pyre disseminates the disease. The dead are worshipped and propitiated by offerings; tree worship is unusual; witchcraft and omens are implicitly believed in; charms of various kinds are universally used.

SCIENTIFIC SERIALS.

THE *Quarterly Journal of Microscopical Science* for April 1889 contains the following:—Contributions to the knowledge of *Amphioxus lanceolatus*, Yarrell, by Prof. E. Ray Lankester, F.R.S. (plates xxxiv.–xxxvi.*b*). Referring to his notes on the anatomy of Amphioxus published in 1875, the author withdraws his confirmation of Johann Müller's statement that there is a pair of apertures on either side of the oral sphincter (velum of Huxley). In reality there are no such apertures at all. Those important structures, described as the "brown funnels," are fully described and excellently illustrated; some few numerical data of importance for the anatomical discussion of Amphioxus are given; some errors which appear to be current as to the existence or non-existence of spaces of one kind or another in the body and gill bars are corrected; and some drawings are given, which represent in a semi-diagrammatic form the structure of Amphioxus, not merely as seen in sections or dissections, with all their obvious drawbacks, but as reconstructed and corrected from the examination of numerous specimens, so that they present as nearly as might be a true conception of the living organism. This excellent paper will be welcomed by all students.—Studies in the embryology of the Echinoderms, by H. Bury (plates xxxvii.–xxxix.). In this memoir the author confines his attention;—to the primary divisions of the cœlom, starting from a stage in which at least two enterocœle pouches are already present;—the hydrocœle; its development and connections;—and to the skeleton, so far as it is developed in the dipleurula stage.—On the ancestral development of the respiratory organs in the Decapodous Crustacea, by Florence Buchanan (plate xl.).

The *Journal* for May 1889 is a special issue, and contains a memoir on the maturation of the ovum in the Cape and New Zealand species of Peripatus, by Lilian Sheldon, Bathurst Student, Newnham (plates i.–iii.). The ovarian structures are fully described in *Peripatus capensis*, *P. balfouri*, and *P. novæ-zealandiæ*. A summary of events in the maturation and fertilization of the ovum in these three species is also given; these are followed by some details of the origin of the ova from the germinal epithelium; the disappearance of the germinal vesicle; the formation of the polar bodies, and the formation of the yolk. Among the many interesting facts mentioned are those in reference to the polar bodies: in *P. novæ-zealandiæ* they appear to be completely absent, but two very prominent bodies are present in the Cape species; they are also in these species exactly similar to one another—a series of facts at variance with Weismann's theories.—With this number is given a series of very valuable indexes: an index to the *Journal* from 1853 to 1888; and one to the Transactions of the Microscopical Society from 1853 to 1868; also to the Proceedings of the Dublin Microscopical Club from 1865 to 1880. These indexes are paged separately, so that they may be bound up as an independent volume.

Engler's Jahrbücher, vol. x., includes the following articles:—The first part of the description of the plants collected by Dr. Marloth in South Africa in 1885–86 (with six plates). The descriptions are prepared by Dr. Engler, with the help of other botanists, and include the Monocotyledons, and Archichlamydeous (Choripetalous and Apetalous) Dicotyledons.—On the anatomical characters of the *Monimiaceæ*, by M. Hobein. This natural order is one as to the position of which various opinions have held; the author's observations strengthen the alliance to Laurineæ, inasmuch as in both orders secretory cells are constantly present.—A monographic review of the species of the genus Primula, by Dr. F. Pax. An attempt to trace the phylogenetic relationships of the species of this large genus.—The second part of the description of Dr. Marloth's plants from

South Africa (with four plates), including the Gamopetalous Dicotyledons, by Dr. Engler, &c.—The Piperaceæ collected by Lehmann in Guatemala, Costarica, Columbia, and Ecuador, described by Casimir de Candolle.—A new plant belonging to the Olacineæ (*Tetrastylidium Engleri*, Schwacke), by W. Schwacke.—An anatomical study of *Scirpus* and allied genera (with one plate), and a key for distinguishing them on anatomical grounds, by Dr. Ed. Palla.—On some mistaken, or little-known Rubiaceæ of South America, by Karl Schumann.—On the flora of Greenland, by Eug. Warming. Including interesting descriptions of the general appearance of the vegetation, as well as the habit of certain species, with a discussion of the origin and relations of the flora. The author concludes that Greenland is not a European province, from the point of view of botanical geography, but has nearer relations to America.—Contributions to the comparative anatomy of the *Aristolochiaceæ* (with three plates), by Dr. H. Solereder. A comprehensive investigation of the structure of both vegetative and reproductive organs.—The volume also includes the usual personal notices, and abstracts of current literature, together with a list of works recently published on geographical and descriptive botany.

Journal of the Russian Chemical and Physical Society, vol. xxi. No 1.—On hexabromtetramethylene, by A. Sabaneyeff.—On the heat of solution of lithium bromide. It is equal to 11·351, and thus occupies an intermediate position between those of LiCl (8·440) and LiI (14·886).—On the action of ethyl iodide and zinc upon paraldehyde, by W. Wedensky.—On the oxidation of erucic and ricinoleic acids by means of permanganate of potassium, by L. Urvantzoff and W. Dieff.—On the formation of cane-sugar from starch in plants, by F. Selivanoff. It was observed in tubercles of potatoes.—Notes by MM. Moltchanoffsky, Alexeyeff, and Kondakoff.—Theoretical researches into the motion of water in the subsoil, by N. Joukovsky. The author concludes from his mathematical inquiry and some experiments that the law of Darcy remains satisfactory if the secondary causes are also taken into consideration and the results are not extended to great distances from the well. As to the corrections of Darcy's law proposed by Kröber and Smreker, they do not yet correspond to all facts noticed during pumpings.—Note by W. Rosenberg on cyclonic movements.

No. 2.—Yearly reports of the Society.—Notes on primary, secondary, and tertiary nitro-compounds, by J. Bevad.—On the general law of contraction which takes place during the formation of solutions of salts, by A. Gueritch; second paper, containing data relative to H_2SO_4 and HCN.—On the action of chlorides and hydrochloric acid upon the photochemical decomposition of chlorine-water, by E. Klimenko and G. Pecatoros. They slacken the decomposition.—On the vapour density of ethyl isocyanurate at various temperatures, by S. Krapivine and N. Zelinsky.—On the dilatation of solutions of salts, by N. Tchernay; third paper, containing tables relative to nine different nitrates.—Note on electrical phenomena due to actinic influences, by J. Borgmann.

In the *American Meteorological Journal* for March, Mr. A. L. Rotch continues his interesting articles on the meteorological services in Europe, dealing in this number with the Paris and Montsouris Observatories. The interest of the Paris Observatory, from a meteorological point of view, is now chiefly in its long series of observations, which date from the year 1666; since the establishment of the Central Meteorological Office, meteorology has not been actively pursued at the Observatory. The Montsouris Observatory was founded in 1871, and deals chiefly with the collection of hygienic statistics, and the application of meteorology to agriculture. It publishes an *Annuaire*, and also a monthly summary in the *Comptes rendus* of the French Academy. Prof. H. A. Hazen contributes an article on anemometer comparisons, and discusses the results of recent experiments in America and in this country, with the view of determining the ratio between the motion of the wind and that of the centre of the cups. The results of the American experiments have been discussed by Prof. Marvin, and will shortly be published *in extenso*. The chief difficulty lies in the determination of a constant factor for all velocities, and of constants for different sizes of cups and arms. Prof. Hazen thinks it possible to construct an anemometer with arms and cups so proportioned as to give a constant factor at all velocities. Lieutenant Finley discusses the frequency of tornadoes in the State of Georgia during the last ninety-four years.

SOCIETIES AND ACADEMIES.

London.

Royal Society, May 9.—"On the Magnetic Rotation of the Plane of Polarization of Light in doubly refracting Bodies." By A. W. Ward. Communicated by Prof. J. J. Thomson, F.R.S.

In repeating Villari's experiment on the rotation of the plane of polarization of light in a spinning disk of heavy glass, placed with its axis of rotation perpendicular to the lines of force in a magnetic field, it was observed that the incident plane-polarized light became elliptically polarized. The elliptic polarization was due to the centrifugal force, which had the effect of stretching the glass along the radii of the disk and compressing it parallel to the axis of rotation. The strained glass in the magnetic field has, therefore, the double property of elliptically polarizing plane-polarized light, and at the same time rotating the plane of polarization. The strained glass therefore acted like a crystal placed in a magnetic field, and so, before Villari's experiment could be properly interpreted, it is necessary to examine how the elliptic polarization and magnetic rotation affect each other. The following investigation is an attempt to solve this question, and its conclusions show that the apparent magnetic rotation in a doubly refractive medium is a periodic function of the length of the path of light in the medium. This hitherto unsuspected result entirely accounts for the effects observed by Villari, and those observed by Lüdtge in a piece of compressed glass.

Villari's results are very similar to Lüdtge's. Villari, by spinning a disk of glass very rapidly, strained it, and on observing the magnetic rotation found it get less and less as the strain got greater and greater. There is, however, one noticeable difference between Villari's strained disk and Lüdtge's strained prism. The disk was free from strain in the middle, the prism free from strain at the ends.

I have repeated Villari's experiment at the Cavendish Laboratory, using, at Mr. Glazebrook's suggestion, an elliptic analyzer to determine the magnetic rotation. With the disk spinning about 200 times a second, the magnetic rotation was reduced from 10° to 6°. This is not so great a diminution as Villari observed, but his glass may have been softer and more easily strained.

Villari thought that the effect he observed was due to the time required to magnetize the glass. That this supposition was erroneous has been clearly established by the experiments of Bichat and Blondlot, and recently repeated by Dr. Lodge. In these experiments the oscillating discharge of a Leyden jar was found to rotate the plane of polarization in time with the oscillations. Before hearing of these results I had myself attacked the problem in a somewhat similar manner. A coil of wire was wound round a piece of heavy glass, and a current alternated 250 times a second by a tuning-fork was sent through the coil. The current was measured by a dynamometer and a tangent galvanometer. The first gave the measure of the current independently of its sign, the second showed that the integral current was zero. When the current was passing it was found impossible to extinguish the light, owing to the rapid alternations of the plane of polarization.

May 16.—"Physiological Action of the Active Principle of the Seeds of *Abrus precatorius* (Jequirity)." By Sidney Martin, M.D. London, British Medical Association Research Scholar, Assistant Physician to the Victoria Park Chest Hospital; and R. Norris Wolfenden, M.D. Cantab. (From the Physiological Laboratory, University College, London.) Communicated by E. A. Schäfer, F.R.S.

"The Toxic Action of the Albumose from the Seeds of *Abrus precatorius*." By Sidney Martin, M.D. London, British Medical Association Research Scholar, Assistant Physician to the Victoria Park Chest Hospital. (From the Physiological Laboratory, University College.) Communicated by E. A. Schäfer, F.R.S.

From numerous experiments, the following conclusions were arrived at:—

(1) The poisonous activity of the seeds of *Abrus precatorius*, the jequirity, resides in the two proteids present in the seeds—a paraglobulin and an albumose.

(2) Both of these proteids have practically the same action. They produce severe conjunctivitis when applied to the eye; and when subcutaneously injected, they cause local inflamma-

tion, œdema, and ecchymosis, and gastro-intestinal irritation, with extrusion of fæces and blood; the general symptoms being, first, a great fall of body temperature, and a condition of stupor, ending in death.

(3) The activity of both these proteids is destroyed by moist heat. In solution, the activity of the globulin is destroyed at between 75° and 80° C., and that of the albumose between 80° and 85° C.

(4) That abrus-poison resembles snake-venom in chemical composition, in the local lesions produced, in producing a fall of body temperature, in causing semi-fluidity or fluidity of the blood after death, and, to some extent, in the effect of moist heat on it. Abrus-poison is, however, much less active than snake-venom.

The following table shows a comparison between the activity of the venom of various snakes and of Abrus:—

Vipera berus (common adder)	Fatal dose in man, 0·0021 gramme per kilogramme of body weight (Fontana).
Hyplocephalus curtus (Australian tiger-snake)	Fatal dose in dog, 0·00485 gramme per kilogramme of body weight; ½ grain in medium size dog (15 pounds).
Cobra	Fatal dose in dog, 0·000079 gramme per kilogramme of body weight; $\frac{1}{10}$ grain in dog weighing 18 pounds (Vincent Richards).
Abrus-poison—	
Globulin	Fatal dose, 0·01 gramme per kilogramme of body weight.
Albumose	Fatal dose, 0·06 gramme per kilogramme of body weight.
Peptic albumoses ...	Fatal dose in dog, any dose over 0·3 gramme per kilogramme of body weight (Pollitzer).

"Appendix to paper on Descending Degenerations following Lesions in the Gyrus marginalis and Gyrus fornicatus in Monkeys." By E. P. France. Communicated by E. A. Schäfer, F.R.S.

Linnean Society, May 24.—Anniversary Meeting.—Mr. Carruthers, F.R.S., President, in the chair.—A portrait of John Jacob Dillenius (1687-1747), the first Professor of Botany at Oxford, copied from the original picture at Oxford, was presented to the Society by the President, who gave a brief outline of his career, and of his personal acquaintance with Linnæus.—The Treasurer having made his annual statement of accounts, and the Librarian's and other reports having been read, a ballot took place for the election of officers and Council for the ensuing year. The President, Treasurer, and Secretaries were re-elected, and the changes recommended in the Council were adopted.—The President then delivered his annual address, to which we refer elsewhere.—A unanimous vote of thanks to the President for his address, coupled with a request that it might be printed, having been passed, the ceremony of awarding the Society's gold medal took place. This medal, having on the obverse a fine bust of Linnæus and on the reverse the arms of the Society, below which is engraved the name of the recipient, was founded last year in commemoration of the Society's centenary anniversary, and is bestowed upon a botanist and zoologist alternately, for distinguished services to biological science. This year it was awarded to the eminent botanist Prof. Alphonse de Candolle, and in his unavoidable absence was handed to his grandson M. Austin de Candolle, who attended on his behalf to receive it. Addressing his representative, the President said:—"Monsieur de Candolle, it is a great satisfaction to me to place in your hands, for transmission to your distinguished grandfather, the Linnean gold medal, in recognition of his many important services to botanical science. These services have been so great, and are so universally acknowledged, that it is unnecessary for me to do more than to refer to them. His many systematic monographs justify his being awarded any honour that botanists can confer. His philosophical treatment of the geographical distribution of plants has greatly advanced this department of science, and his successful codification of the laws of botanical nomenclature has been of the greatest practical service to systematists. But botanists will always look with gratitude to Alphonse de Candolle for the successful carrying on of the gigantic enterprise inaugurated by his father when he undertook the publication of the 'Prodromus Systematis Naturalis Regni Vegetabilis.' By his own work, by securing the aid of accomplished *collaborateurs*, and perhaps not least by the plodding toil of reading the proof-sheets of volume after volume of dry systematic descriptions during the thirty-two years in which he took charge of the 'Prodromus,' he has laid science under a debt which cannot be estimated. The work as now completed contains descriptions of all the Dicotyledonous Phanerogams, and of Gymnosperms, which were known when the different volumes were published, amounting to nearly 60,000 species. By his numerous labours Alphonse de Candolle has added lustre to a name that had already obtained a first place amongst botanists. His son Casimir, by his scientific researches, maintains the credit of that name; and now, in handing this medal to you, Monsieur Austin de Candolle, the representative of the fourth generation, may I venture to hope that this imperfect estimate of the services rendered to science by Alphonse de Candolle may help you to realize the honour of the name you inherit, and encourage you by similar true and honest labour to transmit it with added renown to posterity."—The presentation having been suitably acknowledged by Dr. Marcet, F.R.S., a countryman and relative of the recipient, the proceedings terminated with a vote of thanks to the President and officers.

Anthropological Institute, May 14.—Prof. Flower, C.B., F.R.S., Vice-President, in the chair.—Mr. Arthur Thomson read a paper on the osteology of the Veddahs of Ceylon, and exhibited a complete skeleton and several skulls of these people, Although the skeleton was said to be that of a man of twenty-six years of age, many parts were not completely ossified. The fifth lumbar vertebra was less wedge-shaped than amongst the higher races of man, and hence there was a distinct tendency to a backward curve in this region. Attention was drawn to the fact that the left clavicle was longer than the right by no less than 10 mm., and this may probably be explained by the employment of the left arm in the use of the bow; the left arm was also slightly larger than the right. The scapulæ were small and slender, and the high index, 71·1, indicates a marked difference in shape from that of Europeans. The femora and tibiæ were remarkable for their great length, and in each case the left was the longer. On the anterior borders of the lower extremities of both tibiæ were semilunar facets articulating, in extreme dorsiflexion of the foot, with corresponding surfaces on the necks of the astragali. The extreme length of the articulated skeleton was 1578 mm., which was somewhat above that of the average Veddah, as calculated by Virchow. It appeared from examination of all the available crania that the average capacity of the Veddah male skull is 1321 cc., and that of the female skull 1229 cc. The cephalic index is 70·9. From the data given in the paper the author inferred that, if the Veddahs be not of the same stock as the so-called aborigines of Southern India, they at least present very strong points of resemblance both as regards stature, proportions of limbs, cranial capacity, and form of skull; and that, if physical features alone be taken into account, their affinities with the hill tribes of the Neilgherries, and the natives of the Coromandel Coast and the country near Cape Comorin, are fairly well established.—Some notes by Mrs. R. Braithwaite Batty, on the Yoruba country, and a paper by Mr. H. Ling Roth, on salutations, were also read.

PARIS.

Academy of Sciences, May 20.—M. Des Cloizeaux, President, in the chair.—On the telluric origin of the oxygen rays in the solar spectrum, by M. J. Janssen.—On the complete correspondence between the continuous fractions which express the two roots of a quadratic equation whose coefficients are rational numbers, by Prof. Sylvester.—On the impossibility of diamagnetic bodies, by M. P. Duhem. The author's researches lead to the general inference that the existence of diamagnetic bodies is incompatible with the principles of thermodynamics. The so-called diamagnetic bodies are simply magnetic bodies plunged in a more powerful magnetic medium, in accordance with Becquerel's hypothesis, which assumes that for these bodies there exists one distribution of equilibrium and one only, that this distribution is stable, and that a diamagnetic body is always repelled by permanent magnets.—On the artificial reproduction of the mirage, and on the interference fringes that may accompany this phenomenon, by MM. J. Macé de Lépinay and A. Perot. A process is described, by means of which conditions are realized which are analogous but inverse to those that give rise to the natural mirage.—On the expansion of quartz, by M. H. Le Chatelier. The experiments here described show that quartz undoubtedly undergoes considerable expansion between 480° and 570° C. Above the critical temperature of 570°, it ceases to expand, and on the contrary undergoes a slight contraction. The phenomenon is analogous to that observed in the dimorphic transformations of litharge, of potassium sulphate, and especially of dicalcic silicate.—On the variations of the acid function in stannic oxide, by M. Léo Vignon. The author here resumes his study of the polymerization of stannic acid, dealing more especially with stannic acid prepared by means of stannic chloride; with metastannic acid obtained by the reaction of nitric acid on tin; and with calcined stannic oxide. He finds that there must exist a complete series of stannic acids, whose first term would appear to be the soluble acid, and the last the calcined metastannic acid.—On oxalomolybdic acid and the oxalomolybdates, by M. E. Péchard.—On phosphorous acid, by M. L. Amat. In a previous note (*Comptes rendus*, cvi. p. 1400) the author showed that, under the action of heat, the acid phosphite of soda may lose water, and be transformed to a pyrophosphite of soda. His present researches make it probable that the other acid phosphites behave like the salt of soda, only the dehydratation in their case is much more difficult.—Action of the alkaline meta-, pyro-, and ortho-arseniates on the alkaline earthy oxides, by M. Lefèvre. These researches, which are confined to baryta, strontia, and lime, show that lime has a greater tendency to form chloro-arseniates than baryta, while baryta yields simple compounds more readily than lime. Strontia is intermediate between these two bases.—On the malonates of ammonia, by M. Massol. Here the author describes the method of preparation, composition, and properties of the acid and neutral malonates.—On the proportion of nitrates contained in the rains of tropical regions, by MM. A. Muntz and V. Marcano. Observations taken at Caracas (Venezuela) and at Saint-Denis (Réunion), compared with those recorded by Messrs. Lawes and Gilbert at Rothamsted and by M. Boussingault at Liebfrauenberg (Alsace), show that the quantity of nitrates contained in tropical rains is from five to thirteen times greater than in those of temperate zones. To this abundance of nitrogen under a form easily assimilated must doubtless be partly attributed the exuberance of tropical vegetation.—On the richness of wheat in gluten, by MM. E. Gatellier and L. L'Hôte. Continuing their researches on this subject, the authors arrive at the general conclusion that by careful selection and treatment wheat may be made to yield a high proportion of gluten without any reduction in the abundance of the harvest.—Papers were contributed by M. Martinand, on the alcoholic fermentation of milk; by Dom Pedro Augusto de Saxe-Cobourg-Gotha, on a specimen of crystallized iron glance from Bahia (Brazil), and on the albite of Morro Velho; and by M. P. Termier, on leverrierite (a new phyllite), and on the Bacillarites of the coal-measures.

Astronomical Society, April 3.—The following were elected officers for the ensuing year:—President, M. Faye; Vice-Presidents, M. C. Flammarion, Colonel Laussedat, General Parmentier, and M. Trouvelot; Secretary, M. Gérigny; Vice-Secretaries, MM. C. Detaille and E. Bertaux; Treasurer, M. A. Hentsch; Librarian, M. Mabire. Council: MM. Bischoffsheim, Bossert, Charton, Gunziger, Heman, Hirn, Moussette, Secretan, Oppert, Trépied, Armelin (Admiral), Cloué, Bardou, Moureaux, and Schmoll.—M. C. Flammarion summed up the progress of astronomy during the past year.—M. Faye then took the chair, and remarked that in founding this Society M. Flammarion and his collaborators had created something durable, and had rendered a great service in so doing. M. Faye proposed that the Society should hold an extraordinary meeting in September this year, on account of the Exhibition, which will bring many foreign astronomers to Paris. This proposition was adopted.—M. Guiot sent an observation of shadow cast by Venus.—M. Dumesnil, same observation; also observations of Venus, with the naked eye, on March 6, 9, 15, 23, and 28, from 3 to 4 p.m.—M. Faye made some remarks on the Samoa cyclone, and explained the parabolic path of cyclones in both hemispheres.—M. Junod sent some remarks on the attraction between rotating spheres.

Berlin.

Physiological Society, May 3.—Prof. du Bois Reymond, President, in the chair.—Dr. Blaschko gave an account of his anatomical researches on the formation of the horny layer of the skin. According to his observations the Malpighian layer consists of polygonal cells, which are pierced by so considerable a number of fibres that the cell-substance of each consists of a network of fibres. These fibres pass through two or three cells in succession, thus uniting them one to the other; between them, and external to the cells, is found the intercellular fluid, and similarly a fluid substance in the interior of the cells. The growth of the horny layer begins in the *stratum granulosum*, with the appearance of Waldeyer's keratohyalin granules in the fibres; these granules then become larger, and the fibres disappear. In the *stratum corneum* fibres again make their appearance in the dried cells, which have now entirely lost the nucleus which they possessed when they formed part of the Malpighian layer. The speaker supported his statements by drawings and preparations which he exhibited.—Dr. Goldscheider spoke on the muscular sense, and on the experiments he had made with a view to its analysis. To assist him in his researches he made use of localized anæsthesia, produced by Faradic currents, and of the exclusion of conscious volitional impulses. Perception of motion takes place at the joints, and is unaffected by want of sensitiveness in the skin. The liminal value for the sensation of motion varies greatly for various joints, lying between 1°·30 and 0°·27. The time required for the perception of the motion is very short, and is unaffected by the position of the limb. The muscles are not concerned in perceiving the position of the limb, this being dependent on the visual centre, which is stimulated by local sensory impulses. The perception of weight is similarly dependent on the central nervous system, and the recognition of resistance experienced in raising and lowering weights is brought about by means of the varying presssure exerted by the surfaces of the joints against each other. Owing to the lateness of the hour the conclusion of this communication was postponed to the next meeting.

[*Note.*—In the report of the Physiological Society, NATURE, May 2, p. 24, line 22, *for* "ventral" *read* "dorsal."

May 17.—Prof. du Bois-Reymond, President, in the chair.—Dr. Goldscheider concluded his communication on the muscular sense. He brought forward a mass of evidence in opposition to the view, which has up to the present time been widely spread, that innervation-sensations play an important part in connection with muscular sense. Thus, for instance, the following experiment is opposed to the current view: a given muscle is stimulated electrically (the will thus being excluded), lifts a weight, and gives rise to a distinct sensation of the accompanying movement. On the other hand, a movement may be intended, the innervation-sensation being at the same time distinctly prominent, and still the sensation of movement may be subminimal and not reach its liminal value, so long as the movement when executed is very small. As regards the raising of weights, it must be borne in mind that this is performed by limbs made up of several parts connected by joints; the rigid joints give rise to the sensation of resistance. The speaker summed up the outcome of his researches as a whole in the conclusion that the muscular sense is compounded of three peripheral sensations: of a sensation of *movement* resulting from the displacement of the condyles, of a sensation of *weight* produced by the tension of the tendons, and of a sensation of *resistance* due to the pressure of the articular surfaces against each other. In addition to the above there is still another sensation—namely, of *position*, resulting from pressure, tension, and stretching of the skin and other local stimuli. Prof. Gad gave strong expression to his own view, in opposition to the conclusions of Dr. Goldscheider, that the perception of resistance is not directly a sensation but a judgment, based upon the relation of the movement to the innervation and muscular tension.—Prof. Kossel then expressed his opposition to the views of Prof. Leo Liebermann on nuclein, which he regards as a mixed precipitate of metaphosphoric acid, albumen, and bases of the xanthin series.—He next gave an account of the researches of Schindler, who had sought in the tissues for the bases of adenin, hypoxanthin, guanin, and xanthin, which are all products of the decomposition of nuclein. He found no adenin in the semen of bulls, but only the other three bases, whereas in that of the carp and in the thyroid gland not only adenin but the other three are plentifully present. Schindler had further exposed adenin and guanin to putrefactive decomposition. After prolonged exposure both these bases were entirely decomposed, hypoxanthin having taken the place of adenin, and xanthin that of guanin. In both cases the result is explained by the assumption of one molecule of water and the elimination of one molecule of ammonia.

Meteorological Society, May 7.—Dr. Vettin, President, in the chair.—Prof. von Bezold discussed the modern views on the formation of atmospheric precipitates, which, in opposition to the older views, are based upon strictly scientific principles. At one time it was thought that the precipitates are formed by the mixing of cold air with warm moist air, and since the temperature of the mixture falls to the arithmetical mean of the other two, so much moisture must be condensed as corresponds to the considerably lowered saturation-point which results from the above process. Now, however, it is known that both the rise in temperature of the cold air and the heat set free by the condensation of the moisture must be taken into account, so that in reality very little moisture is precipitated: this was clearly shown by the speaker in a series of examples, both by calculation and by graphic representation. Thus appreciable precipitations occur either very seldom or not at all when masses of air of differing temperatures are mixed together. Precipitation only occurs when a saturated mass of air is directly cooled, such cooling being brought about in nature chiefly by radiation and by the upward flow of currents of air. Hence the precipitations which take place on the lofty sides of mountains as the air rises along them, as a result of its having been warmed, and in cyclones. Since warm dry air is carried into the cyclone from the anticyclone, the clouds formed at the edge of the cyclone are subsequently absorbed; thus the clouds are most dense in the centre where the pressure is a minimum, and are progressively less dense towards the periphery. Dr. Vettin showed several experiments on the movement of smoke inside a glass case which was slowly rotating about its centre. Small vessels filled with ice were suspended in the case, causing downward currents of air, and towards these places the smoke made its way from the periphery in a whirling, screw-like formation.

Vienna.

Imperial Academy of Sciences, March 14.—The following papers were read:—On the oxidation of β-naphthol, by E. Ehrlich.—On the encysting of protoplasm with regard to the function of the cell-nucleus, by G. Haberlandt.—Contribution to the anatomy of the aërial roots of Orchidea, by E. Palla.—Results of comparative researches on the spectra of cobalt and nickel (sealed), by A. Grünwald.—Contribution to the systematic knowledge of Muscaria (sealed), by F. Brauer.—On the intestinal mesenteries and omenta in their normal and abnormal state, by C. Toldt.—On the oxidation of paraphenylenediamine and paramido-phenol, by E. von Bandrowski.—On some phenomena of electrical discharges and their photographic fixation, by A. von Obermayer and A. von Hübl.—On the elements of the geological structure of Rhodus, by G. von Bukowski.—Determination of the orbit of the Andromeda (175) planet, by F. Bidschof.

Amsterdam.

Royal Academy of Sciences, April 20.—Prof. van de Sande Bakhuigzen in the chair.—M. Martin read a paper on the so-called "old-slate formation of Borneo." This formation is known among others in the western parts of the island, where a few fossils were collected by the mining engineer, C. J. van Schelle, viz. at the Soengli Molsong, and near Boedoek and Sepang, in the "Chinese districts." It appeared, on examination, that these fossils belong to the genera Gervillia and Corbula, and as neither genus ever occurs in Palæozoic strata, the "old slate" here cannot be Palæozoic. The slates are, moreover, covered by Tertiary strata, so that the only alternative is to assume that they belong to the Mesozoic age. A further confirmation of this hypothesis he found in the fact that he had succeeded in finding, in a grey limestone of the Bojan, in the Upper Kapoes dominion, *Orbitulina centicularis*. As this fossil is Cretaceous, and the limestone in question occurs likewise in company with clay-slate, he concluded that the strata with Gervillia and Corbula are of the same age as those with Orbitulina, and that they all belong to the Cretaceous period. M. Martin feels persuaded that the Cretaceous formation is widely spread in the Indian Archipelago, and, on account of the absence of fossils, has been partly included among the "old slate," and partly among the Tertiary system.

Stockholm.

Royal Academy of Sciences, May 8.—Prof. S. Lovén gave an account of a recently published memoir, by Prof. J. Steenstrup in Copenhagen, with the title, "On the Station of the Mammoth Hunters at Tredmort in Moravia."—Baron Nordenskiöld exhibited the first copy, now ready, of his great work, "Facsimile Atlas to the Oldest History of Chartography, containing copies of the best maps printed before the year 1600," a volume in folio, with fifty-one large maps, and eighty-four maps and figures inserted in the descriptive letterpress. The interesting manuscript map of Northern Europe from 1467, discovered by Baron Nordenskiöld in the library of Count Zamoiski at Warsaw, is also copied.—He also exhibited a large meteoric stone, 10½ kilogrammes in weight, which fell on April 3, this year, in the province of Scania.—Contributions to the knowledge of the absorption of the radii of heat through the various components of the atmosphere, by Dr. Ångström.—On the construction of the integrals of the linear differential equations, by Prof. Mittag-Leffler.—Note sur la série généralisée de Riemann, by Dr. A. Jonquière, of Bern.—On the action of cyanium on phenyl-sulpho-urinate, by Herr D. S. Hector.—On the action of some oxidating bodies on phenyl-sulpho-urinate, by the same.—On integration of differential equations in the problem of the n bodies, by Prof. Dillner.—The singular generatrices of the binormal and principal surfaces, by Prof. Björling.—Studies on the peat bogs of Southern Scania, by Herr G. Andersson.—Zoological notes from Northern Bohuslän, by Herr C. A. Hansson.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Unrivalled Atlas (W. and A. K. Johnston).—An Illustrated Manual of British Birds, Parts 11–14: H. Saunders (Gurney and Jackson).—A History of the Study of Mathematics at Cambridge: W. W. R. Ball (Cambridge University Press).—Nature's Voice: H. H. (Vickers-Wood).—The Physiology of the Domestic Animals: Dr. R. M. Smith (Davis).—A Visit to Stanley's Rear Guard: J. R. Werner (Blackwood).—Reports from the Laboratory of the Royal College of Physicians, Edinburgh, vol. i. (Pentland).—A New Theory of Parallels, 2nd edition: C. L. Dodgson (Macmillan).—Life of Sir William Rowan Hamilton, vol. iii.: R. P. Graves (Longmans).—Untersuchungen über die Theorie des Preises: R. Auspitz und R. Lieben (Leipzig, Duncker and Humblot).—Spacial and Atomic Energy, Part 1: F. Major (Eyre and Spottiswoode).—Record of Experiments in the Manufacture of Sugar from Sorghum, 1888: H. W. Wiley (Washington).—Six Species of North American Fresh-water Fishes; Six Lithographs from Drawings by A. Sonrel; Explanation of Plates by D. S. Jordan (Washington).—Transactions of the Academy of Science of St. Louis, vol. v., Nos. 1 and 2, 1886–88 (St. Louis).—Journal of Morphology, vol. ii., No. 3 (Boston, Ginn).—Journal of the Marine Biological Association, New Series, No. 1 (Plymouth).—Journal of the Anthropological Institute, May (Trübner).

CONTENTS.

THURSDAY, JUNE 6, 1889.

REPORT OF THE ROYAL COMMISSION ON A UNIVERSITY FOR LONDON.

THIS Report is a disappointment. The spectacle of three eminent lawyers taking an eminently legal view of a question, and three teachers an educational view, is instructive and amusing, but it is not business. Passing over, for the present, the question how far its conclusions are discredited beforehand, by the dissent, on the material point at issue, of all the Commissioners who have had experience of teaching, we shall consider the principal Report from our own standpoint; which is that of a complete impartiality as between the University of London, the petitioning Colleges, and the other institutions and interests concerned, and of an earnest desire to see established in London a real University for teaching and research—that is to say, one of which the function is the dissemination and advancement of knowledge, while the examinations are relegated to their proper place, as accessories to study, not fetters on the teaching.

At first sight the impression is favourable. "The general case for a teaching University is," in the Commissioners' opinion, "made out." The limitation of its area to London, so far as concerns its teaching functions, is strongly insisted on, and reiterated in several paragraphs. The rejection of a separate University for Medicine is good in itself, and is of good omen, when the position of the two leading Commissioners is considered, for a future association with the University of the only possible London School of Law, that of the Inns of Court. The Commissioners have adopted some excellent ideas as to the constitution of Faculties, consisting exclusively of actual teachers, and as to the formation from the Faculties of Boards of Studies. They further "think it desirable to give a definite value to the training and teaching which those students will obtain who go through the prescribed courses of constituent colleges and teaching institutions connected with the University," and they formulate certain proposals for their exemption from specified examinations, which at least serve to show that the recognition thus given to the value of systematic study under competent guidance is not, in their minds, a purely nominal one. There cannot be a doubt that, if their recommendations were adopted, the administration of the University of London would be improved, and the influence of its examinations upon study, in London at all events, greatly modified for the better. We do not see why, subject to some further consideration for the case of students elsewhere than the Commissioners have cared to give, the reforms suggested in the Report should not now be carried out, as it proposes, by the independent action of the University of London, with hearty support and approval from the University Colleges, and without in the smallest degree impairing their case for the simultaneous establishment as a separate institution of a real teaching University for London.

But this, of course, is not the intention of the Commissioners. On the contrary, they recommend, in so many terms, that if this reform should take place in the University of London, "the prayer of University College and King's College be not granted." This obliges us to examine whether the reform in question will insure to us that further benefit to be expected from the establishment of a teaching University which lies apart from any possible good results to follow upon the mere perfecting of the machinery of examinations. Upon this head it is our deliberate judgment that they will fall short of what is needed. It is not the somewhat stinted amount of representation upon the Senate which is offered to University College and King's College; not the representation on a more liberal scale of teachers in the University Colleges and schools, arranged in Faculties for the purpose, upon the same body; not even the appointment by these Faculties of so-called Boards of Studies, limited to the function of advising the examining body; nor yet all these concessions taken together, which will transform a general examining body into a teaching University for London, as we understand the term. Far less will such a University be constituted by "confederating" or "co-ordinating," for examining purposes only, all the "various societies and institutions in London which profess to give advanced teaching," such as, for example, "the Birkbeck Institution, the City of London College, and the Working Men's College." In the Charter of the Victoria University it is expressly provided that the affiliated Colleges shall be, for teaching purposes, efficient. This necessary safeguard has been overlooked by the Commissioners. There remains the recommendation that "the University should have power to teach by professors and lecturers of its own, attached or unattached to particular Colleges or institutions, and to receive endowments for that purpose." Assuming the necessary endowment to be forthcoming, the bearing of this proposal depends on its application. If the University Colleges are willing to allow of the "attachment" to them of University professors—that is to say, to allow the University to appoint the leading members of their teaching staff—and if further they permit the University "Boards of Studies" to arrange their prospectuses, then, indeed, the result will be that the Colleges, for teaching purposes, will become merged in the University; and we shall have, at the expense of the sacrifice of their individuality, and not without considerable violence to their traditions, a strong and homogeneous teaching University in London. Otherwise, one of two things will happen: the separate University staff may be a mere peripatetic staff of lecturers, doing what is known as "University extension" work; or else it will constitute a third University College, with a privileged position, competing with others for their students. In neither of these cases shall we have reaped the characteristic benefit of a teaching University, which is, shortly, the organization of teaching power.

Thus, on the most careful examination we have been able to give to the proposals of the Report, we are brought to the conclusion that only on one condition—a condition very unlikely to be realized—will they result in giving us a real teaching University for London. In default, we shall have a general examining University as before, but one largely under the control of London teachers. The change will entail a violence to the traditions of the University, and perhaps a disparagement of its Imperial position. The Commissioners, indeed, say: "For other parts of the Kingdom, as for the Colonies, it is sufficient that there should be access, as heretofore, to examinations and to degrees." This dictum, a curiously inaccurate one, if we consider the recent foundation of the Victoria University, not to speak of Colonial and Indian teaching Universities, will hardly be accepted by the country Colleges which still look, and must for some time continue to look, to the University of London for degrees. They will claim representation on its governing body, if not also on its Faculties and Boards of Studies; and if its functions are restricted to the control of examinations, we do not see on what principle the claim can be refused. The refusal to admit institutions at a distance is justifiable if the first business of the University is to teach; but hardly plausible if its function is only to examine.

Nor is this all. In order to obviate "the risk of practical injustice being done to candidates for degrees from country Colleges or from no Colleges at all," the Commissioners propose to establish what they call a "balance in the government of the University and in determining the course of the examinations and the choice of examiners," between the associated institutions and "independent elements." This they attempt by assigning a majority in the governing body to Crown nominees and the representatives of Convocation. This provision will in no way help to keep the University in touch with the teaching of the country Colleges; but it will undoubtedly entail the risk, which has been overlooked by the Commissioners, of producing a want of flexibility in the administration of the examinations, considered as accessories to study in the London Colleges. The University will thus start on its teaching career with a clog about its movements. Differences of opinion are sure to arise among its administrators, as often as an alteration of its programme is proposed in the interests of the London teaching; and these will be differences which no wisdom or moderation will entirely obviate, because they will be due to a fundamental difference in the point of view. We strongly apprehend that an institution so framed will be found to contain within itself the seeds of failure. In any case it will hardly obtain that large measure of confidence from the Colleges which would lead them to intrust it with any power over their teaching.

The initial fallacy of the whole Report may be traced to a little word in the twelfth page of it, paragraph 15. The Commissioners say: "Whatever difficulties there may be in the way of establishment of such form of connection as may be desirable between a teaching University for London and the different bodies and agencies now engaged in kindred work on an independent footing, we think it probable that these difficulties may be more easily overcome if *the ground* were occupied by one University only, and not by two." The ground proposed to be covered is not one field of work, but two. There is the work of affording by means of a general examination a test of attainment for students in institutions of as yet imperfect efficiency, and for private students. There is also the work of organizing the teaching, with its examinations closely following and dependent on the teaching, in the efficient Colleges of London. The two differ essentially, not merely in area, but in purpose. The attempt to devise an instrument competent to regulate both at once has failed, as it was bound to fail. Whatever line is now taken by the University of London, we trust that the promoters of the movement, who have succeeded hitherto so far beyond expectation, will stand fast by their principles, and not forfeit, by a too great eagerness for immediate results, the success which is certain ultimately to crown their efforts.

TASMANIAN GEOLOGY.

Systematic Account of the Geology of Tasmania. By Robert M. Johnston, F.L.S. Pp. 408, with Geological Map and Sections, and 57 Plates of Fossils. (Hobart: Published by the authority of the Government, 1888.)

NEARLY forty-five years have elapsed since Count Strzelecki and Prof. J. Beete Jukes, working independently, made known to geologists the main features of the important island of Van Diemen's Land. In the interval between the publication of their researches and the present day, numerous papers treating on questions of local geology have been published by Mr. Charles Gould—who for a time was engaged in making a geological survey of the colony—and by many amateur geological investigators. No complete description of the geology of the whole colony has as yet appeared, however; and we therefore heartily welcome the large and comprehensive volume now lying before us, as supplying a long-felt and pressing want.

The author of this work, Mr. Robert M. Johnston is the Government Statistician and Registrar-General of Tasmania; and during the last sixteen years he has devoted much time and labour to the study of the geology and natural history of the colony in which he resides, and has published numerous papers dealing with questions of stratigraphical geology and palæontology, as well as of botany and zoology. In the year 1884, Mr. Johnston was requested by the Tasmanian Government to write a general treatise on the geology of the island; and the present work has been prepared during the leisure hours of a busy Government official.

The Island of Tasmania has an area of a little more than 26,000 square miles, or between four and five times that of Yorkshire. Over large parts of the island there is a covering of almost impenetrable scrub; while the rivers are large enough to make traverses of the country by no means an easy task; and the rainfall is heavy. The interesting details of the methods of exploration, given in the introductory chapter of this work, illustrate the nature of the difficulties which have had to be overcome in making the researches upon which the work is based. We cannot but admire the energy and zeal which have been exhibited in carrying out the numerous and valuable observations that have made the present work possible.

The excellent sketch-map of the geology of Tasmania, drawn on a scale of 15 miles to the inch, gives a very good idea of the general distribution of the several rock-masses. The oldest formations appear on the west and on the north-east of the island, and consist of crystalline schists, apparently belonging to the Archæan periods, associated with clayslates, quartzites, sandstones, and limestones of Cambrian, Ordovician, and Silurian age, with some small and doubtful representatives of the Devonian. The palæontological evidence concerning the age of the different Lower Palæozoic rocks appears to be of a fairly satisfactory character.

Lying in the district between the two areas of older rocks, we have, in the central parts of the island, a tract of great extent, which is occupied by the important coal-bearing strata. These strata have, however, been greatly invaded by igneous extrusions, and are, over a considerable area, covered up by Tertiary deposits. While the lower series of these coal-bearing strata contain the remains of plants, like those of the Carboniferous strata of Europe and the United States, the higher Coal-measures yield many plants having Mesozoic affinities.

Mr. Johnston, like all who have had to deal with the geology of countries in the East and in the southern hemisphere, has been compelled to confront a very serious difficulty—that of making his nomenclature and classification fit in with the scheme that has been adopted in the countries which happen to have been the first systematically studied by geologists. His biological training and knowledge have here, however, stood him in good stead; and there are few contributions to this difficult question more worthy of attentive consideration than the chapter of this work which deals with nomenclature and classification, and the suggestions offered by the author on the subject of the "distribution of genera in time, from independent or widely separated geographical centres."

Mr. Johnston divides his Tertiary strata into the two groups called by him Palæogene (including perhaps the Eocene, Oligocene, and Miocene of European geologists) and Neogene (corresponding with our Pliocene). It is perhaps unfortunate that in the latter case a name is employed which has also been used by the geologists of Eastern Europe with a somewhat different signification.

Coming down to post-Tertiary times, the author gives an excellent account of the caverns and native shell-mounds, containing the rude flint-implements of the aboriginal inhabitants. Portraits are given of the last surviving man and woman of the Tasmanian race (King Billy and Truganini), the former of whom died in 1869 and the latter as recently as 1876. Drawings of the rude instruments made of chert which were used by this interesting race of human beings, and details concerning the mode in which the natives employed the different kinds of weapons, will prove of great service to those engaged in studying the remains left by various ancient races in Europe and America.

Full justice is done to the different kinds of igneous rocks, so far as they have yet been studied; to the various economical products; and especially to the useful ores, of the island. Interesting details are given concerning the mode of occurrence of the "Tasmanite," or "white-coal," which attracted so much attention a few years ago, and first led to the investigation of many similar "spore-coals" in Europe and America. The character of the deposits from which stream-tin and gold have been obtained is also described, and their importance is indicated by accurate statistics: the value of the tin obtained in Tasmania is now shown to be between £300,000 and 400,000 per annum. Nor are more purely scientific and theoretical questions neglected. An interesting discussion of the probable distribution of land and water in the Australasian region before and during the Tertiary period is illustrated by sketch-maps; and here, too, the author's biological knowledge has aided him greatly in dealing with a very complex and difficult problem.

But quite independently of the scientific value of the work, which as we have seen is certainly very great, we think the Government and people of Tasmania are to be congratulated upon the character of this remarkable and handsome volume. It aims at being above all things of practical use, and its great object is to direct the attention of the colonists to questions of pressing interest and importance, as well as to secure their aid and co-operation in solving the important problems presented by the geology of the country.

The bibliography of Tasmanian geology has, with the assistance of Mr. Robert Etheridge, Jun., been very amply dealt with. Chapters containing a key to the determination of rocks, and instructions for the blowpipe examination of minerals, together with an excellent glossary of geological terms, which might seem out of place in a memoir on European geology, will make this work of service to many colonists who have not had the advantage of a scientific training or access to libraries. The numerous plates, too, if not so highly finished in some instances as we are accustomed to in works of the kind, serve their purpose admirably; and the plan of giving side by side with the imperfect fossils found in the colony a number of well-marked types from the other Australian colonies, and even from Europe, can scarcely fail to prove of the greatest service to many a traveller or resident in the country, whose only work of reference may be this volume.

In the execution of his task, which has evidently been a labour of love, the author has received much assistance from the geologists in other Australian colonies and in New Zealand, and this he warmly acknowledges. No less valuable has been the co-operation of many of his fellow-colonists, who have aided him by drawing plates, in making special inquiries, and in many other ways.

When invited to undertake the work, the author was requested to prepare a volume which should be "specially suited for the guidance of local students, mining prospectors, and others." We can heartily congratulate Mr. Johnston, and the Government which have so liberally paid for the publishing of the book, upon having not only completely accomplished their primary object, but of having at the same time issued a work which is of the highest scientific value. It is not often that the wants of the general public and of the scientific specialist have been so admirably met; or that a book has been produced, which is at the same time accurate and thorough in its treatment of technical questions, while it is not wanting in the more elementary details required by those who have not had the advantages of a scientific training.

JOHN W. JUDD.

CACTUS CULTURE FOR AMATEURS.

Cactus Culture for Amateurs. By W. Watson. Profusely Illustrated. (London: L. Upcott Gill, 1889.)

QUAINTNESS of form, extraordinary brilliancy of colour in the flowers, facility of cultivation, all supply reasons why these plants, independently of the scientific interest attaching to them, should be extensively cultivated. At one time succulents were fashionable. They were grown, and grown well too, in the most unpromising localities—on the leads of London houses, in back yards, in cottage windows. They may still be found in the latter position, where the conditions often seem to suit them better than in more specialized habitations, probably because the plants get full exposure to light, and a dry atmosphere, while they are at the same time relatively impervious to dust. Barring occasional survivals, succulents have, however, "gone out." A collector recently dead did his best to galvanize the public taste. Regardless of expense, he got together a superb collection. With unwonted generosity he lent large assortments to public institutions, where they might be seen of many. With even greater liberality he gave away great numbers of plants to schools and other institutions, as well as to private individuals. He hoped by so doing to revive the public taste for this class of plants. Vain hope! They are no more abundant now than they have been for the last quarter of a century; the nurseries have mostly discarded them as unprofitable lumber; the great collections are broken up. Even the assemblage to which we have just alluded has been recently sold under the hammer, and, despite its excellence, realized scarcely more than enough to pay for the hammer. Under these circumstances it was with no little astonishment that we saw a series of articles in the *Bazaar* some time since, and it is with even greater surprise and pleasure that we now welcome their republication. The publisher, it seems, noting the general absence of cactuses in English gardens, came to the conclusion that the reason for their exclusion was to be found in the absence of adequate knowledge as to their cultivation and management. He thereupon commissioned Mr. Watson, Assistant Curator of the Royal Gardens at Kew, to write a series of chapters on the subject. Brave publisher! may he be amply compensated for his chivalrous efforts! At any rate, he pursued a wise instinct when he secured the services of Mr. Watson. While private collections have, as we have said, almost disappeared, these plants have always been very well represented at Kew. The succulent house indeed is, and always has been, one of the most striking features of that grand establishment. While of exceptional interest to the naturalist, the cactus house appeals to the attention of the general public more forcibly, if not always more pleasurably, than any other department of the Gardens. Ten years' experience in the care and cultivation of these plants at Kew is alleged by the author as his justification in publishing the present book. But, in truth, the book furnishes its own vindication. It is written for gardeners, not for botanists, but it will be acceptable to both, and we shall not be greatly surprised if the book is more appreciated by the naturalist than by the gardener. Fashion rules in gardening as in other things, and Fashion says now we will have cut flowers and roses, and we will have orchids; by and by, perhaps, it will demand cactuses, although they do not furnish "cut flowers," and this demand will, we trust, be furthered by the book before us.

The naturalist is, if not wholly, still largely, beyond the influence of the caprices of Fashion. For him the limited geographical distribution and the extraordinary forms of these plants, their surprising adaptations to the conditions under which they grow, their remarkable metamorphoses, the absence or extremely reduced condition of their leaves, the co-relative thickness of stem and expansion of surface, offer a never-ending source of interest and investigation. The wonderful provision against undue evaporation, the protection against the ill effects of radiation, the amount of green surface exposed to the sun even in the practical absence of leaves, the defence against thirsty marauders afforded by the spines, the singular nature and arrangement of those spines—all these points, to say nothing of the, in many cases, incomparably gorgeous flowers, give these plants claims on the attention of philosophic naturalists beyond those offered by most others. Further, with occasional exceptions they are easily grown, demand relatively little space, attention, or expense, and are therefore specially fitted for the naturalist of moderate means.

Lastly, we may commend them to the attention of those botanists who have the management of botanic gardens. Those who have visited the smaller University Gardens in Germany or France know what depressing establishments they generally are, and how little they seem to contribute to the advancement of science; but if the managers of each garden were to take up the cultivation, one of one genus of plants, one of another, as means and opportunities permitted, they might do excellent service to botany at little cost, and in these specialties achieve results not possible of attainment in larger and more exacting establishments. The Bromeliads were taken up in this manner in the Liége Botanic Garden by Prof. Morren, who unfortunately did not live to complete his monograph. We allude to the subject here because no group of plants affords better opportunities for a thorough and comparative study of the inter-relations of structure, development, and life-history generally than does the order Cactaceæ. Whilst fashion fades and palls, the interest of scientific investigation is not only continuous but progressive. The cactuses are replete with problems of deep import to naturalists, and we trust that Mr. Watson's book may be the means of bringing about the solution of some of them.

OUR BOOK SHELF.

Lehrbuch der Vergleichenden Anatomie zum Gebrauche bei vergleichend anatomischen und zoologischen Vorlesungen. Von Dr. Arnold Lang, Inhaber der Ritter-Professur für Phylogenie an der Universität Jena. Erste Abtheilung. (Jena: Gustav Fischer, 1888.)

THIS "Lehrbuch" is the ninth edition of E. Oscar Schmidt's well-known "Handbuch." It has been thoroughly revised—indeed, in parts rewritten. As might be expected from the Professor of Phylogeny at Jena, the subject is treated from a quite modern standpoint. We have first the systematic arrangement of the tribes, orders, and classes of each group or sub-kingdom, with the characteristics of each. This is succeeded by some general observations on the group, then the general morphology is described, next we have the details of the various systems; the illustrations to the descriptive part of each chapter being selected with great care and judgment, and being in most cases refreshingly new. This first part of the volume commences with the Protozoa and ends with the Vermes. With the immense advance of zoological knowledge it may be regarded as impossible that any one person can have an equal knowledge of all the groups into which the animal kingdom is now divided; and while at once acknowledging the care which has been shown in the compilation before us, one has only to study the chapters on the Plathelminthes and Vermes to find how the author's special and great knowledge of these groups has made this the most valuable portion of the present part. The Protozoa are divided into three classes—the Monera, Sarcodina, and Flagellata; among these last, such genera as Pandorina, Stephanosphæra, and Volvox are included without a hint being given that many regard them as plant forms. The Cœlenterata are divided into the Gastræadæ, Porifera, and Cnidaria, and the former class is made to include not only the Orthonectidæ and Dicyemidæ, but also the Physemaridæ. In the quoted literature on this group no reference is made to Prof. Ray Lankester's very impartial paper on a species of Haliphysema. These facts are referred to, not as criticisms on this valuable addition to an already large list of introductions to a study of the comparative anatomy of the animal kingdom, but rather as in their way indicating the standpoint from which this one has been written. The printing is excellent, and the style of the work is worthy of the house of Gustav Fischer, of Jena.

A Manual of Practical Solid Geometry. By William Gordon Ross, Major R.E. (London: Cassell and Co., Limited, 1888.)

THIS book follows in the main the lines of geometrical drawing as studied at the Royal Military Academy, Woolwich. It will be found to be a useful help to those who desire to have the power of producing accurate and workmanlike drawings. Orthographic projection of points, lines, and planes, system of vertical indices, and projection of curves and solids, are first dealt with, and are followed by simple cases of regular solids and solids of revolution, illustrated by drawings in elevation and plan. A series of solid geometry problems are next worked out on the index system, figures being drawn in the more difficult cases. Problems in connection with irregular surfaces, and relating to the defilade of works of fortification, are worked out, and also illustrated by drawings. The appendix contains a collection of examples of different kinds, and various hints and suggestions useful for draughtsmen.

Key to Lock's Elementary Trigonometry. By Henry Carr, B.A. (London: Macmillan and Co., 1889.)

THE examples given in this book are fully and clearly worked out, and in the elementary examples the author has added considerable detail to enable those reading the subject for the first time, and those who are studying it without the help of a teacher, to obtain a clear insight into the working of them. Great care seems to have been taken to insure accuracy, and from beginning to end a teacher would find it hard to add much in the way of supplementary explanation.

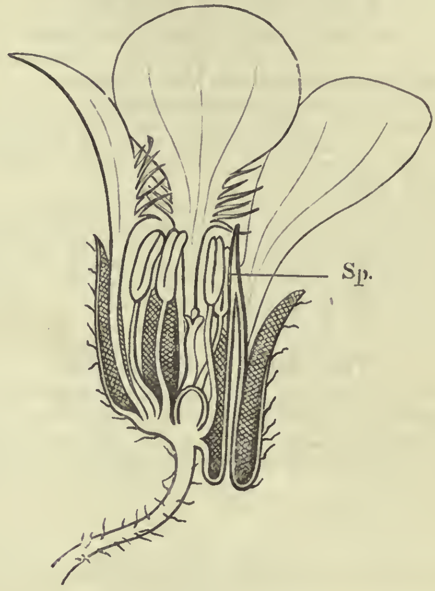
LETTERS TO THE EDITOR.

[*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.*]

Abnormality in Tropæolum.

IN the early summer of last year my attention was directed to a case of abnormality in flowers of Tropæolum, which I think is sufficiently interesting and rare to be worthy of record.

I observed three distinct plants of several years' growth (in a conservatory) to be producing flowers in considerable numbers which were peculiar in having the spur either completely or partially *invaginated*, as shown in the figure.



In examples where the invagination is complete, the intruded spur occupies the exact position of the stamens, and it is a fact of some significance that it is not uncommonly double.

Flowers of the normal form were also developed, and I noticed that as the summer advanced the proportion of these increased until eventually the plants produced only flowers of the ordinary kind. They are again flowering this season, and are repeating their behaviour of last year in every detail.

I am not aware of any similar case having been recorded either in Maxwell Masters's "Vegetable Teratology" or elsewhere. The facts brought to light by the examination of numerous examples seem to me to suggest a new interpretation of the nature of the "spur" in this flower, which I purpose discussing at a later period. In the meantime I shall be very glad to hear of any similar instances either in this or any other "spurred" flowers. ALFRED DENNY.

Firth College, Sheffield, May 27.

The Structure and Distribution of Coral Reefs.

IN reply to Mr. Guppy's letter permit me to state that (owing to Captain Wharton's kindness) I had before me, when writing, the Report on the Survey of the Tizard and Macclesfield Banks. That reef-building corals occasionally grow at depths considerably greater than 25 fathoms was already known (see "Coral Reefs," second edition, p. 115, note), and Commander Moore's investigations did not appear to me to do more than confirm this. Mr. Guppy, I think, must have read his copy of the Report rather hastily, or he would hardly have failed to quote the following "suggestive remark" which occurs on p. 16:—"This fact [a living astræan at 45 fathoms] proves that the fine sand of the lagoon is not necessarily fatal to the solid reef-building astræan, and helps to explain how individual coral heads appear in the deep waters of these atolls, but it cannot be doubted that their growth is very limited. . . Coral growth is most luxuriant between 2 and 12 fathoms." T. G. BONNEY.

Atmospheric Electricity.

NOT once only, but on several occasions, I have been alarmed by the fizzing of my ice-axe in the Alps.

Twice in one neighbourhood—the Riffelberg—I have been in company with several tourists who have (as I myself) been considerably frightened.

It must be remembered that the Riffelberg and the Gorner Grat contain so much iron as to affect the compass observations of surveyors. How often may this be a determining cause?

Alpine Club, May 28. MARSHALL HALL.

Unusually Large Hail.

SOME very large hailstones fell here about 3.30 p.m. on Sunday, June 2, during a short but sharp thunder-storm. Most of them were ellipsoidal in outline; some were mammillated, and some were evidently compound, formed of several hailstones partially fused together. Ten picked up at random as being fairly large ones measured from $\frac{7}{8}$ to $1\frac{3}{4}$ inches ($\frac{7}{8}$, $\frac{7}{8}$, 1, $1\frac{1}{8}$, $1\frac{1}{8}$, $1\frac{1}{8}$, $1\frac{1}{2}$, $1\frac{1}{2}$, $1\frac{3}{4}$, $1\frac{3}{4}$ inches) in greatest diameter. Many of them were formed of four, five, or six concentric layers, which were alternately clear and snow white. Some of these hailstones lying on the grass took more than an hour and a half to melt away (temp. 65° F.)

Mr. I. C. Thompson has just drawn my attention to the residue which they leave when melted on a clean glass slide. This, when examined under a high power of the microscope, is found to contain, along with inorganic particles, a number of minute plant spores.

W. A. HERDMAN.

University College, Liverpool, June 2.

The Muybridge Photographs.

ALLOW me to state, in order to save correspondence due to the omission of a publisher's name in connection with the Muybridge photographs (NATURE, May 23, p. 78), that they may be seen and ordered of Mr. Muybridge, at 38 Craven Street, Strand, London.

E. RAY LANKESTER.

University College, London.

THE VICES OF OUR SCIENTIFIC EDUCATION.[1]

THE subject which I desire to bring to the notice of the Association to-day must necessarily remind you of the attack which was recently made on our competitive examination system in the *Nineteenth Century*.

In some respects the writers of the article, or articles, in the *Nineteenth Century*, appear to me to have right on their side when they object to the existing state of our competitive system.

They begin by complaining against the dangerous mental pressure, and the resulting physical mischief, which accompany the working of nearly all parts of our present educational system. This complaint seems to me to be just.

The fact is, in my opinion, that nearly all our examinations are much too difficult—too much beyond the mental and physical abilities of the examined.

Let me take, as a supreme instance, the examination for the Mathematical Tripos at Cambridge. Ever since I have known anything of this examination, I have wondered how it can be possible that young men, three years after leaving school, can successfully grapple with problems, a great number of which are of transcendent difficulty, in such an immense range of mathematical and physical subjects as this Tripos contains. Indeed, when we are admitted behind the scenes by reading the solutions of these problems by those who have set them, our wonder is increased; for we find frequently that the discussion of a single problem occupies four, five, or six (and sometimes more) pages of small print. Such problems have a very great value for the student who has plenty of time to consider them in the solitude of his study; but I should think that the attempt to attain the amount of knowledge and adroitness necessary to deal with them on the spur of the moment in the Senate House must often produce mental and physical injury. Are we really to believe that a young man of twenty-one or twenty-three has made himself master of nearly everything given to the scientific world by Newton, Laplace, Gauss, Jacobi, Helmholtz, Cayley, Thomson, and Clerk Maxwell?

The desire to place before a student a standard which (I suppose I am right in assuming) he can never reach is, of course, quite defensible; and it is one which appears in every educational competition. But it is not in all cases carried out with a regard for rightness of method. For, this desire to be always in advance of the student leads some examining bodies to hurry him through a large number of subjects in a short time. It is, I think, a marked characteristic of our very modern method that we require half a dozen branches of mathematics and physics to be got through in a time which, say, twenty years ago, would have been devoted to the study of two or three. Is there, for example, nearly so much time now devoted to the study of pure Geometry as there was then? Is Trigonometry so thoroughly and leisurely studied now in the schools?

With the rage which now exists for rushing students through elementary mathematics in order that they may in the shortest possible time reach physics, both experimental and mathematical, the necessary foundations of scientific knowledge are seldom properly laid. Boys who ought to be learning skill in Algebraical manipulation, in assimilating Trigonometrical formulæ, and in applying them to various problems of Mensuration, are, I find, endeavouring to limp through Statics, Hydrostatics, and Kinetics. When to these comparatively advanced subjects we add some Chemistry, the phenomena (at least) of Heat, Optics, Sound, Electricity, and Magnetism—to say nothing of languages—the result is inevitable that the less showy subjects of elementary pure Mathematics must be insufficiently studied—must, in fact, be merely skimmed.

There is no subject in which the result of this overhaste is so easily recognized as Trigonometry; for, at the outset, the student's work in this branch must largely consist in committing to memory a number of formulæ, and nothing but long-continued practice in application will fix them in the mind. Hence, as the necessary time must be given to several other subjects, I find very many students exceedingly slow in repeating, and even in recognizing, some of the most elementary and frequently useful formulæ in Trigonometry. Hence also a large portion of the knowledge brought out in competitive examinations consists of what is called "Cram," and it is, therefore, customary to heap odium on the "Crammers." I do not think, however, that the fault rests with the Crammers, who do merely what they are invited to do by educational authorities.

I shall take as an instance of the excessive haste with which students are pushed on through various branches of Science the Matriculation Examination of London University; and what I say with reference thereto is the result of a present experience which I have in assisting a young relative in his reading for this examination. In last year's Regulations for Matriculation you will find that the course of Mathematics consists of Arithmetic, Algebra as far as easy quadratic equations with questions involving their use, Geometry to the extent of the first four books of Euclid, with simple deductions; and in Mechanics the requisites are "elementary notions as to Velocity, Acceleration, Force, Mass, Momentum, Work, and Energy, Composition and Resolution of Velocities, Accelerations, and Forces in one plane. Moments and Couples in one plane. Centre of Gravity, or Mass-centre. Transmission of Pressure in Liquids; variation with depth of the pressure due to weight of liquids. Specific Gravity and modes of determining it. Pressure of gases, and laws relating thereto. Atmospheric pressure. Common instruments and apparatus whose action depends upon the pressure of liquids, or of the atmosphere, or both." In addition to this, the candidate must take up either Chemistry, or Heat and Light, or Electricity and Magnetism.

Now you will observe particularly two things about this prescribed course. Firstly, the candidate is not supposed to have any knowledge of the fifth and sixth books of Euclid, and therefore no knowledge of the propositions relating to the ratios of linear or other magnitudes; and, secondly, that all knowledge of Trigonometry is excluded.

[1] A Paper read before the Association for the Improvement of Geometrical Teaching, January 19, 1889, by Prof. Minchin, President.

What boy with this slender knowledge of pure Mathematics is likely to have a correct notion of the nature of Acceleration? And, without knowing the meaning of a sine or a tangent, to what can his knowledge of the Composition and Resolution of Forces and of the method of taking Moments amount?

A course of reading in Mechanics and Hydrostatics, specially constructed so as to avoid Trigonometry and the sixth book of Euclid, is a curious object to contemplate. It reminds one of a number of large boulders thrown out into a stream, with painfully and dangerously wide intervals between them, their tops barely above the water, to enable a man to get across by a series of courageous jumps; and, as in the case of such a traveller, not all the caution nor the acrobatic deftness of balancing on the point of one foot which he possesses will prevent him from tumbling off his flimsy and rickety supports, so in the case of the student for whom knowledge has been packed up into a number of scientific boluses, it is impossible to avoid the acquisition of erroneous notions and fallacious rule-of-thumb principles, which, assimilated thus early, have a strong tendency to remain rooted in the mind.

In the case of my young friend I found it quite impossible to impart anything that could with propriety be called a knowledge of Mechanics without the aid of Trigonometry. In the Composition and Resolution of Forces a few questions made specially to order, which usually depended on the facts that the sine and cosine of 45° are equal, and that the sine of 30° is $\frac{1}{2}$—although, of course, the mention of a sine or cosine was inadmissible—exhausted the field; and the same restrictions were imposed on the treatment of Moments, so that I was obliged to abandon the task, and to insist on a small knowledge of Trigonometry and the sixth book.

In such a cramped and stunted knowledge there is nothing of spontaneity, nothing of power, but much of danger. It is far better to give no encouragement to it, to defer the attempt to study the elements of mathematical physics until the old and well-recognized branches of elementary pure mathematics have been studied with some thoroughness.

The want of thoroughness which seems to me to be so prominently characteristic of our works on mathematical physics sometimes exhibits itself, quite unconsciously on an author's part, in a ludicrous manner. It may, perhaps, be best described as "Calculus dodging." For some curious reason, which I have never discovered, it has been generally assumed that a student can possess a very extensive knowledge of the results and principles of Dynamics—of the composition and resolution of forces and couples in three dimensions, of the principle of work and energy, of the nature and properties of tubes of force, Potential, &c.—without any knowledge of the Differential or Integral Calculus. This is, surely, a piece of self-deception. The processes of differentiation and of elementary integration are not difficult of acquirement, and it seems to me that they ought to be studied before such an extensive inroad is attempted into Dynamics. But, presuming that such knowledge is not possessed by the reader, we find the author performing such an integration, for example, as that of $\frac{dx}{x}$ between specified limits by a process which must strike an intelligent student as at once most ingenious and most unnatural. Special devices exhibited "for this occasion only" confer no independent power on the student, and, moreover, require him to possess an amount of ability which would be much better and more successfully employed in acquiring a knowledge of the principles of that Calculus which is thus evaded by artifice.

In all such cases it may be said, I think, that a student who is capable of understanding the notions involved will arrive at the results by other than the special artificial methods employed by the author; while in the case of a student for whom such methods are necessary, most probably the notions are unsuitable, and the method of proof is apt to puzzle him with what seems to be mathematical jugglery.

If more time were spent in teaching the mathematical principles on which quantitative physics depends, there would be less need for such methods, and in the long run the student of physics would be a gainer.

But, while advocating a more thorough and leisurely study of the elements of pure mathematics before the study of physics, it seems to me that many of our elementary text-books in mathematical physics make the mistake of occupying the student's attention with questions which, being far removed from physical reality, and being, in fact, merely disguised mathematics, had much better be omitted. We should make the effort to make our works on physics as physical as possible, to use Mathematics for the sake of Physics, and not *vice versâ*; and it is time to recognize that the field of physics is now so extensive as to supply subject-matter for calculation and for illustration of mathematical principles, and to permit us to curtail greatly the space which is now devoted to things comparatively useless.

Let me take one or two examples. Is anything gained by teaching students the very numerous properties of the curve which a particle would describe if it were projected with any velocity, under the influence of gravity, if the Earth had no atmosphere?

Again, let us turn to any work on Hydrostatics, and we are certain to find a very large number of mathematical trivialities. I say nothing of a number of liquids, whose densities are in some kind of progression, superposed in very fine tubes of peculiar shapes. These are harmless; but what about that notion of *whole pressure* on a curved surface—the sum of all the normal pressures, or, more strictly, the surface-integral of pressure over the curved surface?

Numerous, indeed, are the mathematical problems to which this notion gives rise; but what about the physical idea involved? It is easy to comprehend the trouble which a teacher lays in store for himself if he practises his students in the process of adding together the magnitudes of a number of forces whose lines of action are in all directions in space. And remember that, in most cases, very few students who are taught to calculate the whole pressure of a fluid on a curved surface will subsequently learn that a similar process has a physical meaning only in the case of the normal flux of Newtonian gravitation through a curved surface. Let us see, however, the physical meaning which is actually attributed to the whole pressure of a curved surface by the author of one of our very elementary text-books for students. The following is the literal statement:—"It should be observed that these pressures act in different directions, the pressure at each point being perpendicular to the surface at that point. The whole pressure is the sum of all these pressures, and represents the total strain to which the vessel containing the fluid, or the body immersed, is exposed." Now in this statement, besides the addition of the magnitudes of a number of non-co-planar forces, we have the misuse of the term *strain* and the completely unintelligible expression "total strain" of the vessel. And, in illustration of this definition, we are given the following example: "Show that if a sphere or a cube be filled with liquid, the total strain to which it is subjected is three times the weight of the liquid it contains." You will, I hope, agree with me in holding that such teaching is in the highest degree erroneous and objectionable, and that the efforts of those who have to teach should be directed against it.

So far as my observation goes, the principle making Physics a mere disguise—and a very unskilful one—for pure mathematics is much too largely adopted by writers on mathematical physics, with the result that many students receive very insufficient practice in acquiring and developing physical conceptions.

To this cause, also, must be attributed the fact that proficiency in mathematical physics is a much rarer thing than proficiency in pure mathematics, the former being made, to such a great extent, subservient to the latter. Indeed it was not, I think, until the publication of Thomson and Tait's "Natural Philosophy" that the ancient problem-grinding system, which hindered the progress of exact Physics, received a severe blow, and Cambridge, under the influence of the ideas and methods of Thomson and Clerk Maxwell, produced a plentiful supply of physicists.

But the good that was effected by Thomson and Tait is confined almost entirely to advanced students; in the hands of those of a lower standard are still to be found text-books of the old sort, teaching Mathematics under the guise of Physics, presenting nothing but the dry husks of the latter, and, by inaccurate language, laying an early foundation of erroneous notions. Some people of the older school—not a few—express, indeed, a strong impatience with us if we protest against the use of slipshod and inaccurate language in our text-books. They tell us that we are doing the matter of nomenclature to death, and that, after all, we need not be very particular about the choice of exact terms. This is a most unfortunate attitude; it is one, however, which this Association has done, and is doing, something to counteract. Surely it must be admitted that if the conceptions of Physics are presented to the beginner in erroneous language, there is a danger that in many instances these conceptions will never be properly acquired. And is not accurate language as cheap as inaccurate?

I know of several text-books still in the hands of schoolboys and others in which, in whole pages of answers to problems on the motion of a particle, *velocity* is always spoken of as so many feet, and *acceleration* also as so many feet—no reference being made to *time*, and the fact that acceleration has a double reference to time being never mentioned. I assume it as evident that the progress of such students is seriously hindered and delayed by such teaching.

If the writers of such text-books as those to which I refer have really clear and correct notions themselves, they ought to take pains to present them accurately to beginners who have to learn from them. Not to do so is to ignore the fact that a great deal of the difficulty of learning any branch of science is removed if only the student is started upon it with clear and correct notions as to the various entities with which the science deals, and with its fundamental principles expressed in accurate language.

Let us take, as another example of exceedingly erroneous teaching, the following exercise—one of a great many, all similarly expressed—from a text-book still in the hands of beginners: "The time occupied by a body in describing uniformly a complete revolution in a circle, whose radius is 11 feet, is 16 seconds, calculate the centrifugal force which acts upon it. *Ans.* 1·696 feet per second."

In this we have two bewildering errors instilled into the student's mind, viz. that *force* is measured in feet per second, and that when a body is revolving in a curve, it is acted upon by an *outward* normal force—the old time-honoured fallacy about centrifugal force. It is almost miraculous that any accurate scientific knowledge is acquired in spite of such fallacious teaching as this.

I wish to emphasize this teaching about *centrifugal force*, because, no matter how often it is condemned and shown to be erroneous, it still flourishes in our scientific text-books. In another elementary work which is extensively used, we find the nature of centrifugal force more fully explained in the following manner. "In order to keep a body moving in a circle, there must be a force acting upon it which will produce a constant acceleration towards the centre, equal to $\frac{v^2}{r}$. Hence, if W be the weight of the body, P the pressure tending towards the centre, $P = W\frac{v^2}{gr}$." This is, of course, all right; but then follows the mysterious statement, "a pressure equal and opposite to P is sometimes spoken of as the centrifugal force."

I call this a mysterious statement, because it does not tell us on what this pressure equal and opposite to P acts, or whether it really acts on anything at all or not. We know, of course, that this reversed force is the reaction of the moving particle on the agent or surrounding medium; but how is a beginner to know this? Will he not naturally fall into the error of supposing that it acts on the moving body itself? Or, if he possessed a little intelligence, would he not ask, "Why do you require me to think of a force equal *and opposite* to one which acts on the body? I have nothing to do, when considering the motion of the body, with any forces except those which act on the body itself; and why do you not ask me to consider a force equal and opposite to some of the other forces acting on the body—a force equal and opposite to its weight, for instance? It would be just as sensible to do so, since this reversed weight is the body's reaction against the Earth."

The only true reply to such a student is to confess that it is quite a mistake to introduce the conception at all; but instead of this, we find that the discussion proceeds to encourage the erroneous notion that centrifugal force acts on the moving body by taking the case of a carriage describing a curve of small radius.

Now, what is it that has given rise to this fallacy about centrifugal force? Is it the fact, so often adduced, that, if we tie a stone to one end of a string and, holding the other end in the hand, whirl it round, we feel an outward force pulling the hand? But then, if we imagine the stone to be attached to an elastic string, one end of which is tied to the hand, while the stone is projected vertically upwards, the hand would experience an *upward* pull; and are we thence to conclude that the stone is continually acted upon by an *upward* force?

Possibly the whole fallacy is traceable to D'Alembert, who gave us a sort of dynamical *memoria technica*, usually expressed in the words, "forces equal and opposite to the effective moving forces of a material system are in equilibrium with the external forces,"—a very imperfect and misleading statement for the principle obviously contained in Newton's first and second axioms, viz., "the mass-accelerations of the particles of any material system have at each instant *the same* total component along any line, and *the same* total moment round any axis as the external forces acting on the system."

D'Alembert's fictitious reversal is unnatural and unnecessary; and, in introducing fictitious forces and reducing the state of the moving material system to one of equilibrium, he ignored the actual state of affairs. He should have faced the state of motion as it exists, and recognized the fact that the production and maintaining of a given state of motion requires the action of a definite system of forces assisting the motion, instead of concentrating his attention on something which would stop the motion. It is this determination to fix the mind on a state of equilibrium, and to ignore the actual motional state that is, I think, responsible for the fallacy of centrifugal force.

[Other examples of erroneous teaching with regard to centrifugal force, the confusion of *work* with *horse power*, &c., were then given.]

We must remember, also, that a teacher who has often to correct the erroneous language of the text-book which he employs with his class is by no means certain of inspiring confidence in himself and convincing his pupils that the teaching of the author is at fault; for, young students, very unlike Prince Bismarck, have a profound respect for printer's ink; hence they are always disposed to believe that the book is right, and if you tell them that an acceleration is not so many *feet*—as the book says it is—but so many *feet per second per second*, they accept the correction for politeness or for peace sake, but not with any conviction.

In addition to numerical calculation as an important aid in the teaching of Mathematical Physics, I would also advocate the employment of *graphic methods of solution* in cases in which exact solution is not possible. The graphic method of solution is scarcely recognized at all in our text-books. Every text-book of Statics gives us, indeed, its modicum of graphic representation, which is usually exhausted in a bare and barren exposition of the principle of the *triangle of forces* and the *polygon of forces*, which has long since become stale "book-work."

But this is by no means what I advocate. I intend graphic solution at once as an aid to calculation, as a means of strengthening the student's interest in the subject, and as a representation to the eye of the possibilities and limitations of any particular problem under discussion.

[The problem of the equilibrium of a camp-stool was then given as an illustration of the graphic method.]

In Statics and Hydrostatics we have abundant instances of this kind, and their solutions by the graphic method furnish excellent practice for the ingenuity of the student, giving to each problem the interest which a vivid picture always gives, as well as strengthening his knowledge of the results and methods of pure Mathematics.

The sum total, then, of what I have said with reference to our elementary text-books comes to this—that, while we are abundantly supplied with high-class scientific works of an advanced character, a corresponding improvement has not generally taken place in the books from which school-boys and other beginners have to learn; that these books are often marred, not only by inaccurate language and fallacious teaching, but by a certain scrappiness in their mode of treatment which is encouraged by the desire of examining bodies to hurry through and skim over a large number of scientific subjects at the expense of a more leisurely study of the foundations of Science.

I should like, in conclusion, to say a few words with regard to the way in which the cramming of Science is encouraged by examinations.

Wherever well-worn book-work is set at an Examination, it is extremely likely that cram will find its opportunity, and it may be impossible for an examiner to detect it. Assuming that book-work must be set, I do not know of any reliable safeguard against cramming except *vivâ voce* examination. But a *vivâ voce* examination which is made a part of the competition, and in which the candidates do not all get the same questions, is, I think, essentially unfair. Whenever such an examination is possible, its function should be to discuss with each candidate the several questions with which the written paper deals. In this way, when his knowledge of any particular question or method appears to the examiner of the written paper to be doubtful, the doubt is very speedily settled one way or the other. But, in the absence of such a corrective, an examiner who is, after all, dissatisfied with the candidate's working of any particular question, and yet disinclined to allow him no credit whatever, is obliged to resort (at least in many instances) to some systematic method of cutting off marks, and this method is not infrequently a system of elaborate trifling.

As a particular example, take a question which is sometimes set at examinations in Science—the method of determining H, the horizontal intensity of the Earth's magnetic force. A part of the process consists in the discussion of the vibrations of a uniform magnet bar round a vertical axis under the influence of the horizontal magnetic force. Such a bar is a compound pendulum, and its motion involves a knowledge of its moment of inertia and the integration of a differential equation of the second order. If at any instant θ is the angle made by the axis of the bar with the magnetic meridian, the expression $\frac{d^2\theta}{dt^2}$ is involved in the equation.

Now, I know a case in which the whole of this process was crammed up by a candidate who, although he had a good practical knowledge of Physics, did not know how to resolve a force along a line, did not know the meaning of the moment of a force about an axis or of the moment of inertia of a body about an axis, and, of course, was wholly ignorant of the meaning of the expression $\frac{d^2\theta}{dt^2}$. Indeed, this last was a puzzle to him, for he always failed to place the two figures "2" in their proper places. Yet the whole thing was crammed up with sufficient success to obtain credit for the question.

In such a case as this an examiner may have very grave suspicions, but he may be obliged to give a large measure of credit, nevertheless. Frequently the method of marking such an answer is something like this—the expression $\frac{d^2\theta}{dt^2}$ involves two *d*'s, two 2's, a *t*, and a θ; if the candidate uses all these symbols, each in its proper place, give him full marks; if he uses all the symbols, but *one* is misplaced, take off *one* mark; if *two* are misplaced, take off *two* marks; and so on. This is of course an exaggeration, but it is the *kind* of system adopted—necessary, perhaps, but extremely unsatisfactory.

Now a *vivâ voce* examination of the candidate on this question would, in a few seconds, have decided his mark to be *zero*.

In cases in which the number of candidates is very large, it would seem to be impossible to apply a *vivâ voce* test; but there are cases in which it could be used, and used, I have no doubt, with good effect.

The setting of book-work at examinations is, I think, much too frequent. It gives a hope of success to candidates who really have no vocation for a subject, but who load their memories sometimes with whole pages of work of which they understand almost nothing.

Our examination system has its defects; but these defects are almost wholly due to the shortcomings either of individual examiners or of the directors of education.

I have spoken of the excessive haste with which educating bodies compel students to attempt the acquisition of a large and varied assortment of knowledge; but I must not omit to add that the evils of examination are greatly aggravated by the prodigious haste which is imposed on examiners themselves in some public competitions. Nothing can justify a system which requires an examiner to read over and determine the numerical value of every one of 1200 papers in little more than a fortnight. The thing is utterly impossible, and the results must be untrustworthy.

But, whatever the defects of the examination system may be, I hold that the *principle* of examination is good.

[Some of the objections of the writers in the *Nineteenth Century* were then dealt with in detail. Referring to the unsatisfactory method by which professors and lecturers are now appointed, Prof. Minchin continued:—]

Mr. Frederic Harrison says, "Trust the teacher; trust him to teach, trust him to examine;" and I should say that, if we did, we should find our trust far more often misplaced than it would be by trusting wholly to the independent examiner. If the teachers were always people who could teach, the case would be different; but what is the method of appointing teachers, as a rule, in England? People make inquiries as to what scholarships, prizes, and degrees, have been obtained at the University by a candidate for a teaching post; but of his capacity for imparting successfully any of his own knowledge to others there does not, in most instances, exist the slightest proof; and hence we are often presented with such lamentable teaching failures. Under these circumstances it would be ridiculous to "trust the teacher, trust him to teach, trust him to examine;" for, bad as examiners are, teachers are worse—partly for the same reason as that for which white sheep eat more than black, viz. that there are more of them.

And is it not also vain to attempt to replace the Examination system, even at the Universities, by a system of Thesis writing on some particular subject selected by the candidate, the Thesis being written by him at home, with ample opportunity for composing it out of works of reference, or with the assistance of his friends, with the addition of a small make-believe of "original research?"

We are told by one of the writers in the *Nineteenth Century* that, under our Examination system, England is losing her intellectual giants, men who are a head and shoulders above their contemporaries; but I ask is the writer aware that we have still among us Sir William Thomson, and that we have only recently lost Clerk Maxwell? People who speak thus seem to think that we are to expect a crop of intellectual giants to sprout up like a crop of mushrooms, and to be ready whenever we want them.

I would say in conclusion—let us retain Examinations, make them tests of a knowledge of the applications of principles, so that they will be real tests of intelligence, and not of cram; do not make them so difficult and so high-flown as they often are; and, finally, do not encourage the hurrying and skimming through a large number of different subjects, but make sure of the foundations by a more thorough and leisurely system of study.

THE LIFE-HISTORY OF A MARINE FOOD-FISH.[1]

I.

It is but a few years since the life-history of our most important marine food-fishes was involved in considerable obscurity—not only as regards popular views, but even in respect to the knowledge of men of science. Thus, for instance, in the years 1883 and 1884 the almost unanimous opinion of British fishermen was that our common food-fishes sought the shallow water of the bays and inshore ground generally for the purpose of depositing their eggs on the bottom. No observations specially bearing on this point had been made by British zoologists, and a series had to be undertaken for a public inquiry then in progress—with a result which demonstrated how extensive the reverse of the popular notion was. Again, certain comparatively recent authors on British fishes speak of a common fish like the gurnard as spawning twice a year, whereas, after careful observation, no evidence in support of this view has been obtained. The same obscurity veiled the larval and post-larval conditions of most of the food-fishes, even G. O. Sars—in regard to the latter stage—describing no intermediate forms between the larva of 6 mm. and the post-larval stage of 24 mm. in the cod, almost the only fish to which some attention had been paid.

On the other hand, our knowledge of the development and life-history of the fresh-water fishes—such as the salmon, trout, and charr—has for many years been well understood—thanks to the labours of Louis Agassiz and Vogt in Switzerland, Coste and Lereboullet in France, Ransom in England, and Shaw in Scotland, on the scientific side, and of the noblemen and gentlemen of Perthshire (ably seconded by Robert Buist) in connection with Stormont Field Ponds on the Tay, on the popular side. Much information has also been recently obtained by Dr. Day and Sir J. Gibson Maitland at the excellent ponds of the latter at Howietoun.

[1] A Discourse delivered by Prof. W. C. McIntosh, F.R.S., at the Royal Institution, on Friday, February 1, 1889.

A short time ago, relying on experience derived from fresh-water fishes, not a few imagined the eggs of marine fishes as readily visible and tangible objects—possibly associated in their minds with certain practices in trout-fishing, or it may be with the manufacture of caviare. Recent investigations, however, have shown that in most marine food-fishes the eggs are minute glassy spheres which float freely in the ocean. For a knowledge of this fact we are indebted in the first instance to Prof. G. O. Sars, of Christiania, a naturalist trained from boyhood under a distinguished father, and who, by a fortunate appointment to a fishery post in Norway, was enabled to discover that the eggs of the cod, haddock, and gurnard, floated in the water, or, as we term it, were pelagic. He thus opened up a new field in the economy of the food-fishes, which in a great maritime country like ours ought not to have remained so long unexplored.

Lately, however, attention has been earnestly directed to the subject, and the labours of Cunningham, Brook, Prince, and others have made considerable advances in this department.

It is now known that the great majority of our British marine food-fishes—indeed, all our most valuable kinds (including even the sprat and the pilchard amongst the Clupeoids) produce minute eggs—as transparent as crystal, and which float freely throughout the water. These eggs, moreover, are not all shed at once, as in the case of the

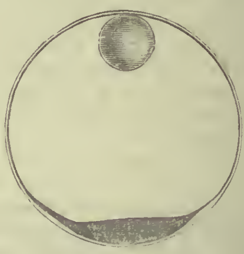


Fig. 1.[1]—Pelagic egg of the ling (enlarged).

salmon, but successive portions of the ovary become ripe, and the eggs then issue externally. If by any accident or irregularity—as for instance the confinement of a flounder in an unhealthy tank—this gradational issue is interfered with, the animal dies from the great distention of the body caused by the pent-up eggs. In the case of the cod this gradual issue of the eggs continues probably for a week or two, so that the progeny of a single fish in one season may vary considerably in size.

From the early months of the year onward to late autumn the sea off our shores thus abounds with pelagic eggs, those of the rockling, haddock, and sprat being amongst the earlier forms, while the later include those of the sole. As indicated in the Trawling Report, and now supported by further experience, it would be a very difficult matter indeed to arrange for a close time in the sea—that is to say, for a limited period during which the mature fishes might be permitted to spawn in peace. This, however, in the case of individual species, such as the cod, might more readily be carried out, so as to save the mature fishes at the spawning period.

In a vessel of still sea-water these transparent glassy spheres rise at once on issuing from the fish, and form a stratum on the surface. Even the ripe portions of ovaries removed from the rejected viscera on a pier will show the same features, and thus, indeed, they first came before the lamented Lord Dalhousie at Anstruther. In the sea, however, they are seldom met with on the surface, and the tow-nets require to be sunk a fathom or two for their capture, their specific gravity being so little less than that of sea-water that they are carried hither and thither by the

[1] I am indebted to Mr. E. E. Prince, B.A., for kindly aiding me with sketches for the woodcuts. The sketch of *Motella* is by Dr. Scharff.

currents in every direction. Some indeed are captured near the bottom by nets attached to the trawl-beam, while experience with the large net of the St. Andrews Laboratory has proved that a great number are carried in mid-water.

When these glassy eggs issue from the female fish, they are soon fertilized in the surrounding water; so that in British waters, at any rate, non-fertilization is one of the rarest conditions in these pelagic eggs. It is indeed more likely to happen in the case of the herring, which deposits its eggs in masses on the bottom, or in artificial circumstances in tanks. The unfertilized egg soon becomes opaque and sinks, so that it is readily recognized.

In this connection I would again refer to the notion not long ago firmly rooted in the minds of many—especially those practically engaged in fishing—that the fishes at the spawning season seek the shallow water in which to deposit their eggs. Now there is little in Nature to support this idea. Shore-fishes, it is true, such as the lump-sucker and sea-scorpion (*Cottus scorpius*), do deposit their eggs there (and there cannot be a doubt that some of the masses of eggs thus deposited have been mistaken for those of the food-fishes); but the edible fishes proper, such as the cod, haddock, whiting, flounders, and others, appear to produce their eggs just where they happen to be feeding at the season. Their eggs are taken in charge by the ocean generally, and hence are independent of any imaginary protection or privilege pertaining to the shallow waters.

Moreover it does not follow that the fishes of an inclosed bay[1] will increase of themselves. As in the case of the plaice, in shallow sandy bays, it may happen that most of the large mature female fishes are beyond the limits, the half-grown or immature forms mainly occurring within; pelagic ova therefore must be borne inward, and still more the pelagic young, while the post-larval stages likewise migrate shorewards; a counter-migration of the older forms subsequently taking place to the deeper water. Such bays, therefore, have to depend for their stock of fishes on the unprotected off shore. If by any chance the latter waters were depopulated, the inshore would seriously suffer.[2]

The minute size of the eggs of all the important marine food-fishes enables a fish like the cod, for instance, to produce an enormous number—probably about 9,000,000, as against the 18,000 to 25,000 of the salmon or the 10,000 to 30,000 of the herring, both of which fishes deposit their eggs on the bottom. In the same way the very small eggs of the dab provide for a large annual increase of the species.

The translucent eggs, which, unless they contain a globule of oil, as in Fig. 1, are difficult to see in some instances even in a glass vessel, thus escape (by floating throughout the water) the vicissitudes to which a purely surface-life would expose them, such as the admixture of the surface-water with rain, and the attacks of gulls, ducks, and other forms; and they also are less at the mercy of the active predatory races living on the bottom, not to allude to the risks of being swept by storms on the beach or captured and destroyed by the ground-rope of the trawler. Nature, indeed, could have devised no method more secure than this for the safe propagation of those valuable fishes which for ages have peopled our waters, and I venture to say, with Prof. Huxley, will perhaps people them for ages yet to come, notwithstanding the persistent efforts of man to annihilate them.

Some good observers, for example Prof. Ryder in America, have attached much importance to the oil-globule in eggs which are pelagic, but its buoyant influence has been slightly over-estimated, for some contain no oil-globule, while the massive oil-globules in the eggs of the salmon and cat-fish have no such effect. They float, as well shown by my friend Mr. Edward E. Prince, Secretary to the Mussel and Bait Committee, solely in virtue of their specific gravity, which is somewhat less than that of sea-water. The moment fresh-water is added they sink, as they likewise often do when transferred from a vessel filled at sea into one containing shore-water.

[1] For example, closed by a Fishery Order.

[2] This feature was pointed out in the Report of H.M. Trawling Commission, under Lord Dalhousie.

While immediately after deposition these minute spheres are prone to accident from impurity and sudden changes in the temperature of the water, such would not seem to be the case after development has made some progress. Thus many living eggs will be found in odoriferous vessels brought from sea by the fishermen if the inclosed embryos have reached an advanced stage. Again, while carrying out some experiments on temperature (at the suggestion of Prof. Huxley) during the trawling expeditions, I had occasion to heat a test-tube containing some of the eggs of the flounder, so as to make them rush up and down the vessel most actively. Considerable heat was applied, and, under the impression that the eggs were irretrievably injured, the tube was set aside. Some days afterwards, when explaining the nature of the experiment to Prof. Ewart, he noticed motion in the tube, and further examination showed that after all this exposure to heat the little flounders had emerged as usual, and were alternately floating and swimming about in the water. On the other hand, severe frosts are fatal to ova crowded in shallow vessels, in many cases actual rupture taking place;[1] and the same occurs in large eggs, for example those of the cat-fish deposited on the bottom of the vessel.

Out of the little glassy sphere, after a longer or shorter interval (varying from a few days to a few weeks, according to temperature), comes a minute and nearly transparent fish which at first is often as passive in the currents as the eggs themselves.[2] It soon, however, uses its tail for swimming and its pectoral fins for balancing. Its shape

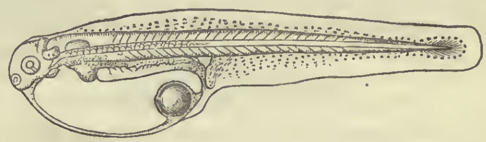


FIG. 2.—Larval ling immediately after hatching.

is somewhat like that of a tadpole, partly from the large head, but mainly from the great size of the yolk-sac, which contains a store of nourishment on which the little mouthless creature, about 3 mm. long, sustains itself for a week or ten days. In this respect it somewhat resembles the young salmon, in which a much larger collection of the same food supports it for about six weeks amongst the gravel in the spawning-bed of the river, though a closer scrutiny reveals certain essential differences. Thus the store of nourishment in the yolk-sac of the salmon is taken up by the blood-vessels which branch in a complex manner over the whole yolk, whereas in the young cod, though the heart is present and pulsating, not a blood-vessel at first is seen, and none ever enters the yolk-sac. The absorption of this nourishment therefore must take place by aid of the cells and tissues themselves, and there is nothing specially wonderful in this, when the condition in the endoderm of *Hydra* and other instances of intracellular digestion are considered.

It has been mentioned that these minute and most delicate little fishes are nearly transparent, and this is more or less the case throughout, though in the majority—even before they leave the egg—points of pigment appear here and there in the skin, so as to give them a distinctive character. After hatching, these pigment-spots branch out in a stellate manner, thus becoming more evident, and it is found that in most cases each little food-fish has

[1] NATURE, June 1886.

[2] For some years the development of fishes has been studied by able workers: amongst others, on the Continent, by Götte, Kupffer, Hoffman, Henneguy, E. Van Beneden, Osjannikov, and Rafaele; in America, by Alex. Agassiz, Ryder, and Whitman; while in our own country, Ransom, Klein, Cunningham, Prince, and Brook have carried out similar researches.

colours of its own. Thus the cod is known by its four somewhat regular black bands, the pigment on the haddock being less defined, the whiting by its canary-yellowish hue, the gurnard by its chrome-yellow, the ling by its gamboge-yellow, the flounder by its yellow and black, and

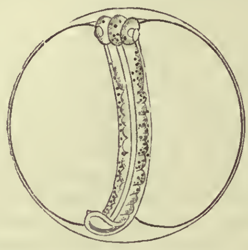


FIG. 3.—Flounder showing pigment *in ovo*.

so on. All these hues, however, become greatly modified during subsequent development; indeed, the pigment in no group of vertebrates shows more remarkable changes between the young and adult states than certain of our food-fishes. Thus for instance the cod is characteristically

FIG. 4.—Larval cod with black spots or bands.

speckled in its tiny youth (Fig. 4), next it becomes more or less uniformly tinted, then the pigment groups itself somewhat irregularly on the sides (Fig. 5); thereafter it is boldly tessellated, subsequently blotched with reddish-

FIG. 5.—Aggregations of pigment in post-larval cod.

brown, and finally in its adult condition it again puts on more or less uniform tints. The ling shows a similar series of transformations, the colours, however, differing in their arrangement, being marked with gamboge-

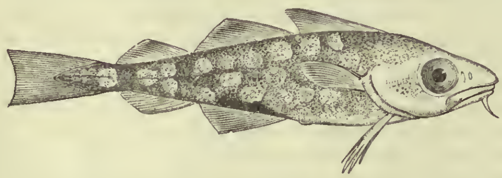


FIG. 6.—Tessellated condition of young cod (spirit-preparation).

yellow in its larval, slightly banded in its early post-larval stage, then the body becomes more or less uniformly tinted in its post-larval phase, and the little fish is furnished with a pair of enormously developed and bright yellow

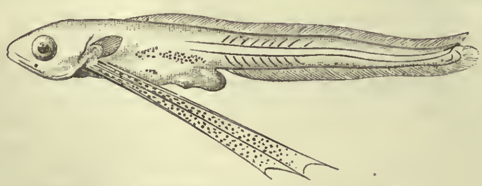


FIG. 7.—Long-finned post-larval ling (enlarged).

ventral fins (Fig. 7)—so different from the short ones of the adult. It is next striped conspicuously when about 3 inches long (Fig. 8), thus affording a great contrast to the tessellated condition of the young cod. In this stage an olive-brown band passes from the tip of the snout in a line with the middle of the eye, straight backward to the base of the caudal fin-rays. The pale ventral surface bounds it inferiorly, while a dorsal stripe with a beautiful opaline lustre runs from the tip of the snout, over the upper part of each eye to the tail, on which it is opaque white, thus giving the fish a characteristic appearance. The dorsal line from the brain backward is distinguished by a narrow edge of dull orange or pale olive, which relieves the colours formerly mentioned, and the general effect is varied by two black specks in the dorsals. When it is double the length (*i.e.* 6 or 7 inches), a complete

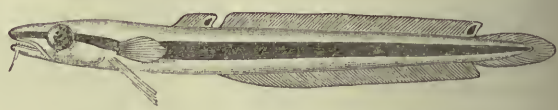


FIG. 8.—Young ling about 3 inches long (in spirit).

change has taken place in its coloration (Fig. 9). Instead of being striped, the fish is now boldly and irregularly blotched—both dorsally and laterally, the region of the white stripe being indicated by the pale and somewhat scalloped area dividing the dorsal from the lateral blotches. Fourteen or fifteen brownish blotches occur between the pectorals and the base of the tail, and they are separated by the whitish areas, which thus assume a reticulated appearance, and both kinds of pigment invade the dorsal fins. Other touches of dark pigment on the fins and tail increase the complexity of the coloration at this stage.

FIG. 9.—Young ling in the barred stage (about half natural size).

Again, some species, like the gurnard, have pigment over the yolk-sac before they are hatched, others have not. The dragonet in its post-larval (and pelagic) stage has its ventral surface deeply tinted with black pigment, while in the adult (a ground-loving fish) it is white. The St. Andrews cross in the eye of the post-larval four-horned Cottus (*C. quadricornis*) is another remarkable feature (Fig. 10). No more interesting or more novel field, indeed, than this exists in the whole range of zoology; but the investigations need ships and boats, with expensive appliances, as well as persevering work for several seasons. We have only been able to open the field at

FIG. 10.—Head of *Cottus quadricornis*, with St. Andrews cross in eyes.

St. Andrews by the help of the Trawling Commission under Lord Dalhousie, and subsequently by the aid of the Fishery Board. It may be asked, Why is all this remarkable variation in colour? Just for the same reason that the young tapirs and wild pigs are striped, or the young red deer spotted—the adults in each case being uniformly tinted. Such features indicate their genetic relation with ancestral forms having these marks; and, moreover, in the struggle for existence, such variations in tint conduce to the safety of the young.

The view of Eimer that the markings in animals are primitively longitudinal would not suit for many fishes, notably for the young cod, ling, and Pleuronectids, and, indeed, Haacke has already pointed this out from a study of the Australian fish *Helotes scotus*,[1] the adult of which is marked by eight longitudinal bands, while young specimens present in addition a row of clear transverse bands which subsequently disappear.

(*To be continued.*)

[1] One of the Pristipomatidæ.

NOTES.

On account of the severe illness of his child, Prof. Mendeleeff was obliged to leave London early on Tuesday morning, very greatly to the regret of those who assembled in the evening to hear him deliver the Faraday Lecture, which was read by the Secretary. It was announced that the dinner, at which the Fellows of the Chemical Society proposed to entertain Prof. Mendeleeff on Wednesday evening, would not take place, but that the President, Dr. Russell, and Miss Russell would receive at the Grosvenor Gallery on Friday evening, as before arranged.

The Ladies' *Conversazione* of the Royal Society will be held on Wednesday, June 19.

The *conversazione* of the Society of Arts will take place at the South Kensington Museum on Friday, June 28.

It has been decided that a statue shall be erected in honour of the late John Ericsson in Stockholm. His biography, papers, and letters will be edited by one of his most intimate friends, Colonel Church, of the American *Army and Navy Journal*.

Dr. George Owen Rees, F.R.S., died at Mayfield, Watford, Herts, on May 27. Dr. Rees took his degree of M.D. at Glasgow in 1837, and became a Fellow of the Royal Society in 1843.

It is requested that all persons having in their possession letters from the late President of Columbia College, Frederick A. P. Barnard, will be kind enough to send them to Prof. Nicholas Murray Butler, Columbia College, New York, U.S.A., at their early convenience. The letters will be returned after copies have been made.

Sir Lyon Playfair, who recently resigned the secretaryship of the Royal Commission of the Exhibition of 1851, has been succeeded by Major-General Ellis, Equerry to the Prince of Wales.

Allen's Indian Mail reports that Dr. Burgess, Director of the Archæological Survey of India, will come home immediately, and that he is retiring from his appointment.

The foundation-stone of the Framjee Dinshaw Petit Laboratory of Scientific Research, in Bombay, was laid on April 8 by Lord Reay. Mr. Petit, the son of the donor, explained that it had appeared to his father desirable, in the interests of medical education, that a laboratory for scientific research in biological and physical sciences should be established. He had long cherished the wish to have the properties of Indian drugs investigated, and made known to medical students. The laboratory, which will be connected with the Grant Medical College, was described by Lord Reay as the only missing link in the educational programme he had sketched out for Bombay.

The Allan Line steamer *Caspian*, which arrived from Halifax at Queenstown on Tuesday evening, reported having passed in the North Atlantic no fewer than thirteen large icebergs. The ship steamed quite close to one of them on Thursday last.

We are glad to be able to report the publication of synoptic weather maps twice a day by the Central Physical Observatory at St. Petersburg, beginning with May 12. The stations for which information is given extend from the west of Ireland to the Ural Mountains and the western shores of the Caspian, and from the north of Norway to the Trans-Caucasus, showing the weather-conditions at a glance, over nearly the whole of Europe. The atmospheric pressure is represented by isobars, and other elements by figures and symbols; the charts being printed on the back of the tabular reports, which have been issued since 1872. A general summary of the weather is given in Russian and French.

We print elsewhere a letter by Prof. Herdman on unusually large hailstones which fell at Liverpool on June 2. A correspondent writes to us from Rock Ferry about the same hailstones. "Five minutes after they fell," says our correspondent, "when the rain had subsided, I examined some. They were then all quite transparent outside, and had a spherical opaque centre surrounded by concentric rings alternately transparent and opaque. Some were flat: the largest I picked up measured one inch by three-quarters of an inch, and a quarter of an inch thick; its edge was very irregular. Others were more spherical in general form, but some still had rhombohedral faces very well defined. It was half an hour before all were melted."

On April 30, about 7 a.m., an earthquake was felt at Sokendal, in Dalerne, on the west coast of Norway. It was accompanied by a rumbling noise like distant thunder, going from east to west. The weather was clear and the wind north-west.

Serious efforts are being made to establish a great National Home-reading Circle Union, and we are glad to learn that they are likely to be successful. One object of the Union will be to publish courses of reading for three classes of readers—young persons, artisans, and general readers. The various courses will be approved by experts, and so planned as to interest and liberalize the mind as well as to convey useful information. Local circles will be formed under suitable leaders, and encouraged to meet frequently for the discussion of the subjects they have been studying. In many different ways the Union will try to aid the readers, and there can be little doubt that the scheme will be of real service to a very large number of persons who have often felt the need of guidance in their attempts at intellectual work. In all the courses science will receive the place which properly belongs to it, but adequate attention will also be given to literature and history.

Does the cuckoo ever hatch its own eggs? Herr Adolf Müller answers this question in the affirmative, and has given in the *Gartenlaube* a full account of a case which he himself claims to have observed. A translation of this account has appeared in the *Ibis*, and is reproduced in the new number of the *Zoologist*. The latter periodical prints also a translation of an article in which Herr Adolf Walter disputes the statements of Dr. Müller, who, he thinks, must have made a mistake. The same subject is dealt with in the June number of the *Selborne Magazine* by Mr. C. Roberts, who quotes from "Zoonomia" an interesting passage, in which Dr. Erasmus Darwin expresses his belief that the cuckoo sometimes makes a nest and hatches its own young. In this passage Dr. Darwin gives an extract from a letter of the Rev. Mr. Wilmot, of Morley, near Derby, describing an instance brought to Mr. Wilmot's notice in July 1792 by one of his labourers, and afterwards closely watched by Mr. Wilmot himself. Mr. Wilmot was confident that the bird was a cuckoo, but this is a point about which most ornithologists would no doubt like to have a little more evidence.

Everyone who takes the slightest interest in natural history will be sorry to learn that the kangaroo is in danger of being extinguished. Its skin is so valuable that large numbers of young kangaroos are killed, and high authorities are of opinion that, unless the process is stopped, Australians will soon have seen the last specimen of this interesting animal. Mr. R. G. Salomon, one of the largest tanners in the United States, whither kangaroo-skin is chiefly sent, urges that a fine should be imposed for the killing of any kangaroo whose skin weighs less than ten-twelfths of a pound; and, from a note on the subject in the *Zoologist*, by Mr. A. F. Robin, of Adelaide, we are glad to see that a serious attempt is being made to secure the enforcement of this restriction throughout Australia and Tasmania, and the proclamation of a close season between January 1 and May 1. We must hope that the Australian Legislatures will understand the necessity of taking speedy action in this matter. It would be scandalous if, in deference to the wishes of a few greedy traders, they were to allow Australia to lose the most famous and most interesting of its characteristic fauna.

AT the concluding meeting of the thirty-first session of the Geological Society of Glasgow, which was held last week, Mr. John Young read a paper on "The Occurrence of Spines within Spines on the Shells of the Carboniferous Productidæ." He said that, though long familiar with the spines themselves, it was only recently he had discovered the peculiar structure he was about to describe. He pointed out that the spines of the Productidæ were tubular, and referred to the varied opinions expressed by those palæontologists who had previously taken up the group for investigation respecting the functions of these spines. Mr. Young said he had now discovered that within the tubes of the spines, of at least four species, there existed a barrier of small spines of microscopic size placed in the tubes just above the junction of the spines with the shell itself. These small spines were planted deeply within the walls of the large spines, and radiated to the centre of the tubes, varying from twenty to forty or more in number. He was inclined to believe that the detection of these minute spines favours the view held by De Verneuil, that the spines themselves conveyed water to the interior of the shell. In illustration of his paper, Mr. Young exhibited under the Society's microscope several beautifully prepared slides showing the presence and arrangement of these remarkable "spines within spines."

A SERIES of new aromatic compounds of bismuth have been prepared by Drs. Michaelis and Marquardt. The first member of the series, bismuth triphenyl, $Bi(C_6H_5)_3$, is a solid, crystallizing in two distinct forms of the monoclinic system, thus forming an example of dimorphism in the same system. In order to obtain it a quantity of the sodium-bismuth alloy is first prepared by melting 500 grammes of bismuth in a Hessian crucible and gradually adding 50 grammes of sodium in small pieces. The resulting hard alloy is then powdered in a warmed metallic mortar, and heated for two days to 160° C. in an oil bath with an equal weight of brom-benzene, C_6H_5Br, a little acetic ether being from time to time added. The filtered product is afterwards distilled until benzene ceases to pass over; water is then added, and the excess of brom-benzene distilled off in steam, the bismuth triphenyl remaining behind unaltered. The cooled residue in the distilling flask is next extracted with chloroform, the chloroform solution separated and dried over calcium chloride. After removal of the greater part of the chloroform by distillation, the bismuth triphenyl is thrown out of solution, by addition of absolute alcohol, as a brown oil. On standing the oil soon crystallizes, and on recrystallization from a mixture of alcohol and chloroform the bismuth triphenyl is obtained in beautiful long colourless monoclinic prisms of brilliant lustre. The prism angle of these crystals is 109° 40′, and the plane of the optic axes is perpendicular to the plane of symmetry. On the other hand, if pure warm alcohol be employed as the solvent, the crystals are found to be quite different, being tabular in habit, but still belonging to the monoclinic system. The principal prism angle is much less than that of the other form, being 100° 23′, and the plane of the optic axes is parallel to the plane of symmetry. No difference of composition could be detected, but the melting-point of the prismatic variety was found to be 78°, while that of the tabular form was 75°. Both varieties are converted by concentrated hydrochloric acid to benzene and bismuth trichloride—

$$Bi(C_6H_5)_3 + 3HCl = 3C_6H_6 + BiCl_3.$$

In a similar manner two higher homologues of the series, bismuth tritolyl, $Bi(C_6H_4 . CH_3)_3$, and bismuth trixylyl, $Bi[C_6H_3 . (CH_3)_2]_3$, were obtained by heating the bismuth sodium alloy with brom-toluene and brom-xylene respectively. Both form good crystals, but no dimorphism was observed. Perhaps the most important property of the compounds is their affinity for chlorine or bromine, for by direct addition they take up two atoms of either halogen, with production of compounds in which bismuth assumes its full pentad atomicity, thus supplying an additional proof of the similarity of bismuth to antimony, arsenic, phosphorus, and nitrogen. For instance, bismuth triphenyl forms $Bi(C_6H_5)_3Cl_2$ and $Bi(C_6H_5)_3Br_2$, the tolyl and xylyl compounds acting precisely analogously. Not only is this the case, but with nitric acid they form dinitrates of the type $Bi(C_6H_5)_3(NO_3)_2$, neutralizing two equivalents of the acid. It is interesting to note that the preparation of these aromatic compounds of bismuth completes a wider series, for the preparation of which we are mainly indebted to Dr. Michaelis and his assistants, as we are now acquainted with analogous compounds of antimony, arsenic, phosphorus, and nitrogen.

A VIPER and a lizard in spirit were lately sent, for examination, to the British Museum by Mr. R. H. Ramsbotham, Waterside, Todmorden, with the following remarks:—"This adder was caught at Trowbers Warren, Sussex, on April 24, 1889, about noon. It was kept in this bottle without spirit till the following morning, between nine and ten, when the bottle was filled. Immediately after this was done, the lizard (which is still in the bottle, and has not been touched) crawled out of the snake's mouth, and was quite lively for a short time." Commenting in the *Zoologist* on this statement, Mr. G. A. Boulenger points out that it includes three facts well worthy of record: (1) that vipers do occasionally swallow lizards, although their food normally consists of small rodents; (2) that in this instance the snake did not avail itself of its poison-apparatus in seizing its prey; (3) that a lizard retained life for nearly twenty-four hours in the gullet of a viper. The lizard is an adult female, *Lacerta vivipara*.

AMONG the contents of the new number of the Journal of the Anthropological Institute is an interesting paper, by Mr. T. W. Shore, on the distribution and density of the old British population of Hampshire. Miss Buckland has an instructive paper on the monument known as King Orry's grave, in the Isle of Man, compared with tumuli in Gloucestershire. There are also valuable papers on Australian message sticks and messengers, by Mr. A. W. Howitt; on social regulations in Melanesia, by the Rev. R. H. Codrington; and on the Nicobar islanders, by Mr. E. H. Man. The number contains Mr. Galton's Presidential address, which our readers have already had an opportunity of studying.

THE "Medical Register" and the "Dentists' Register," for 1889, have been issued. Both are published under the direction of the General Council of Medical Education and Registration of the United Kingdom.

THE Cambridge University Press has issued a second edition of Mr. M. M. Pattison Muir's "Treatise on the Principles of Chemistry." In the preface, Mr. Muir states that the whole has been thoroughly revised, and that Book II., dealing with chemical kinetics, has been entirely re-written.

MESSRS. LONGMANS AND CO. announce as nearly ready, "Physical and Chemical Studies in Rock-Metamorphism, based on the Thesis written for the D.Sc. Degree in the University of

London, 1888," by the Rev. A. Irving, D.Sc. Lond., Senior Science Master at Wellington College. The same publishers have in preparation seven new volumes of their "Elementary Science Manuals."

THE Smithsonian Institution has published a new edition of Mr. Frank Wigglesworth Clarke's "Tables of Specific Gravity for Solids and Liquids." It is, in effect, a new edition of Part I. of the work called "The Constants of Nature." The tables in this "part" have been revised, rearranged, and as nearly as possible brought up to date. The work is issued in England by Messrs. Macmillan and Co.

THE Abbé Armand David, whose writings on the natural history of China are well known in France, is contributing a series of articles to *Les Missions Catholiques* of Lyons on the fauna of China. In the last issue of that journal he completed the papers on Carnivora.

THE *Publishers' Circular* states that a work entitled "The Ice Age of North America, and its Bearings on the Antiquity of Man," by Prof. G. F. Wright, is announced for early publication by Messrs. Appleton and Co., of New York. It will be amply illustrated from photographs taken by various members of the United States Geological Survey during the past ten years.

A WORK on the Island of Saghalin and its vertebrate fauna, by Dr. Nikolsky, has just been published. The author, a native of Astrakhan, is well acquainted with the fauna of the Altai and West Turkestan, and is known as the writer of an interesting work on the fauna of Lake Balkhash. In his new book he has utilized, besides his own collections, the very rich collections formed by the late M. Polakoff.

MR. W. P. COLLINS has issued a catalogue of works on *Cryptogamia*. He claims to possess a more complete set of books on Diatoms than have ever been advertised in a bookseller's catalogue.

WE have received vol. iii., Part 4 (second series), of the Proceedings of the Linnean Society of New South Wales. It contains the following papers:—Revision of the genus *Heteronyx*, with descriptions of new species, Part 1, by the Rev. T. Blackburn; Diptera of Australia—Part 4, the Simulidæ and Bibionidæ, by Frederick A. A. Skuse (Plate xxxix.); further notes on Australian Coleoptera, with descriptions of new genera and species, by the Rev. T. Blackburn; contributions towards a knowledge of the Coleoptera of Australia—No. 5, on certain species belonging to unrecorded genera, by A. Sidney Olliff; descriptions of hitherto undescribed Australian Lepidoptera (Rhopalocera), by W. H. Miskin; notes on Australian earthworms, Part 5, by J. J. Fletcher; descriptions of Australian Micro-Lepidoptera—Part 15, Œcophoridæ (continued), by E. Meyrick; on simple striated muscular fibres, by W. A. Haswell; jottings from the Biological Laboratory of Sydney University, by W. A. Haswell; Diptera of Australia—Part 5, the Culicidæ, by Frederick A. A. Skuse (Plate xl.); list of the Australian Palæichthyes, with notes on their synonymy and distribution, Part 1, by J. Douglas Ogilby; a list of the birds found in the county of Cumberland, N.S.W., by A. J. North.

THE additions to the Zoological Society's Gardens during the past week include a Grey Ichneumon (*Herpestes griseus*) from India, presented by Mrs. Walter Boden; a Serval (*Felis serval* ♂) from Zambesi, presented by Mr. John Walker; an Ocelot (*Felis pardalis* ♂) from America, a Red Brocket (*Cariacus rufus*), two White-eared Conures (*Conurus leucotis*) from Brazil, an Acouchy (*Dasyprocta acouchy*) from British Guiana, a Brazilian Tree-Porcupine (*Sphingurus prehensilis*), a Blue fronted Amazon (*Chrysotis æstiva*), a Yellow Hangnest (*Cassicus persicus*) from South America, a Hairy Armadillo (*Dasypus villosus*), a Pileated Jay (*Cyanocorax pileatus*) from La Plata, presented by Mrs. Wolfe; a Diana Monkey (*Cercopithecus diana*, var. *ignita* ♀), a Campbell's Monkey (*Cercopithecus campbelli* ♂) from West Africa, a Musanga Paradoxure (*Paradoxurus musanga*) from the Indian Archipelago, presented by Colonel Wethered; a Nightingale (*Daulias luscinia*), British, presented by Mr. John Young; a Bar-tailed Pheasant (*Phasianus reevesi*) from North China, presented by Mr. Charles J. Lucas; a Yellow-headed Conure (*Conure jendaya*) from South-East Brazil, a Blue-and-Yellow Macaw (*Ara ararauna*), a Blue-fronted Amazon (*Chrysotis æstiva*) from South America, deposited; an American Jabiru (*Mycteria americana*) from Para, an American Tantalus (*Tantalus loculator*) from America, purchased.

OUR ASTRONOMICAL COLUMN.

NEW MINOR PLANET.—A new minor planet, No. 284, was discovered by M. Charlois, of the Nice Observatory, on May 29.

THE SPECTRUM OF χ CYGNI.—At the Wolsingham Observatory, bright lines were seen in the spectrum of χ Cygni on May 19 and 21; D_3 very plain. Confirmed by Mr. Taylor at Ealing.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JUNE* 9–15.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on June 9

Sun rises, 3h. 46m.; souths, 11h. 59m. 0·6s.; daily increase of southing, 11·6s.; sets, 20h. 12m.: right asc. on meridian, 5h. 11·2m.; decl. 22° 59′ N. Sidereal Time at Sunset, 13h. 26m.

Moon (Full on June 13, 14h.) rises, 14h. 48m.; souths, 20h. 35m.; sets, 2h. 9m.*: right asc. on meridian, 13h. 48·4m.; decl. 5° 45′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	4 52 ...	12 59 ...	21 6 ...	6 11·6 ...	22 6 N.
Venus.....	2 9 ...	9 14 ...	16 19 ...	2 26·1 ...	11 53 N.
Mars......	3 50 ...	12 9 ...	20 28 ...	5 21·3 ...	23 47 N.
Jupiter....	21 18*...	1 13 ...	5 8 ...	18 23·3 ...	23 9 S.
Saturn....	8 28 ...	16 3 ...	23 38 ...	9 15·5 ...	17 7 N.
Uranus...	14 23 ...	19 54 ...	1 25*...	13 7·3 ...	6 28 S.
Neptune..	3 4 ...	10 52 ..	18 40 ...	4 3·7 ...	19 8 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

June.	h.	
14 ...	9 ...	Jupiter in conjunction with and 0° 29′ south of the Moon.
14 ...	20 ...	Mercury at greatest distance from the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
T Cassiopeiæ ...	0 17·2 ...	55 11 N. ...	June 9,		*M*
U Cephei	0 52·5 ...	81 17 N. ...	,, 9,	23 28	*m*
			,, 14,	23 8	*m*
R Geminorum ...	7 0·7 ...	22 53 N. ...	,, 14,		*M*
S Hydræ	8 47·8 ...	3 29 N. ...	,, 12,		*M*
U Hydræ	10 32·1 ...	12 48 S. ...	,, 9,		*m*
W Virginis	13 20·3 ...	2 48 S. ...	,, 10,	3 0	*m*
S Libræ	15 15·0 ...	19 59 S. ...	,, 14,		*m*
U Ophiuchi... ...	17 10·9 ...	1 20 N. ...	,, 12,	0 7	*m*
X Sagittarii	17 40·6 ..	27 47 S. ...	,, 14,	1 0	*m*
Y Sagittarii	18 14·9 ...	18 55 S. ...	,, 14,	2 0	*M*
R Sagittarii... ...	19 10·2 ...	19 30 S. ...	,, 13,		*M*
β Lyræ...	18 46·0 ...	33 14 N. ...	,, 13,	0 0	*M*
η Aquilæ	19 46·8 ...	0 43 N. ...	,, 13,	22 0	*M*
T Vulpeculæ ...	20 46·8 ...	27 50 N. ...	,, 12,	1 0	*m*
δ Cephei	22 25·1 ...	57 51 N. ...	,, 10,	2 0	*m*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
	250° ...	20° S.	
Near ζ Cygni...	318 ...	30 N.	
,, β Piscium	345 ...	0	... Very swift.

NOTES ON METEORITES.[1]

IX.

Did these Swarms or Comets always belong to the System?

MUST we assume that the members of the swarms to which we have referred and of all the other swarms similar to it have always been thus crossing the earth's orbit periodically; that the November swarm, to take an instance, has *always* been crossing it every thirty-three years? Must they of necessity have started their existence with the planets and other more stable members of the system?

This point has been well inquired into, and it is certain that it is not at all necessary that such a state of things should have existed from all time.

It is a matter of common knowledge that all stars are in motion. The so-called "fixed" stars are not really fixed: they are only relatively fixed. The sun is a star, and therefore like the other stars it is also in movement with its attendant bodies in space.

If we have a swarm of meteorites moving in space, as the sun is doing, at a very considerable distance from the sun, the directions of movement being not parallel but inclined to each other, a time will come when the two bodies, taking the swarm as representing one body, and the sun another, will begin to have an attractive influence on each other. If the attractive energy of the sun is considerable as compared with that of the swarm, the swarm will begin to change its direction obviously towards the sun. If, in changing its direction towards the sun and increasing its velocity in consequence of this increased gravitational stress, that swarm can get round the sun without any loss of momentum the two bodies will say good-bye to each other and will go different ways; but supposing there has been a loss of momentum the loss may mean that for the future the swarm of meteorites must perform its journey *round the sun*.

It does not therefore follow that when a particular group of meteorites has been watched for 900 years that these meteorites which give rise to the appearance of shooting stars always formed part of the solar system. What we do know is that *at the present moment* this particular swarm to which the November meteors are due and another swarm which is called the Biela swarm, to mention two instances, do really move round the sun in closed cometary orbits, and the chronicle of the appearances of both these swarms is so complete that very definite statements may be made about them.

With regard to the November swarm it is known that a thousand millions of miles of its orbit have been pierced by the earth in its successive passages through it since the year 902, each time the earth must have filched many millions of the small constituents of the swarm and used them up as shooting stars, and yet the swarm does not seem to be very much the worse, and enormous though the numbers are, it is known that the distances between the meteorites is so considerable that no obvious mutual gravitational effect can be noted, so that their combined or common movement is a clear indication of a common origin.

In the case of the orbit of the Biela swarm we know that more than half of it, or a length of 500 million miles, contains these meteorites; a long thin line, say a mile long and an inch in section, represents, according to Prof. Newton, the distribution of the meteorites along the orbit.

The great Laplace was the first to suggest that many comets, especially those of high inclination and great eccentricities, represented introductions of matter into the solar system from external space. But on this, as on many other points, we owe our present views chiefly to Schiaparelli, who, in 1867, attacked the problem[1] in connection with his researches on the November swarm.

[1] Continued from vol. xxxix. p. 402.

He commenced by referring to the point made by Laplace as to the phenomena presented by cometary orbits, suggesting that the planets are truly indigenous to the system; have always followed the sun in his movement through space; and had taken part in all the evolutionary changes which have finally brought the solar system to its present condition. In these characters common to planets the comets are lacking, while the eccentricities of their orbits generally is so great that the greater part of their journey is performed outside the known limits of our system. Schiaparelli considers that these facts demonstrate that the comets were not members of the solar system during its early stages, but that they are really messengers from the stellar void. Cloudlike masses wandering in parts of space where there was no star sufficient to dominate them have fallen gradually under the empire of our own by the effect of their movement relatively to our system. This movement, combined with the acceleration produced by the large mass of the sun has determined the relative orbits of these bodies in relation to the sun, which is very different from their absolute orbit in space. He next examined all the circumstances of the movement of the external mass under these conditions. First, there is no doubt that the movement of the solar system in space is comparable to that of the planets in their respective orbits, while it is possible—indeed certain—that many of the stars are in more rapid movement than our sun. Hence when it is affirmed that the relative movement of the sun and of other bodies disseminated through space is comparable in rapidity to the orbital movement of the planets, the statement is not a surprising one.

That being so, let us next suppose that one of these cloudlike masses—let us call them external swarms—wandering in space in consequence of its initial movement, penetrates eventually into a region where the attraction of the sun is much greater than that of any other star. It might be situated at a very great distance from the sun, where the annual parallax is only a small number of seconds. The relative movement will take place in a conic section. To define it, let us suppose the sun stopped, and let us give to the comet, instead of its real velocity in space, its relative velocity to the sun; and let us further imagine a perpendicular dropped from the sun in the direction of this relative velocity. It is evident that the area described by the comet round the sun in unit time will be equal to the half of the product of this perpendicular by its relative velocity.

Now as in general this velocity is of the order of planetary velocities, and since most frequently the perpendicular in question will be very much greater than the distance of the planet from the sun, we must conclude that the areas described by the comet round the sun in unit time will be incomparably greater than the corresponding areas described by the planets. But when many bodies move in conic sections round a central body, the areas described in unit time are, among themselves, as the square roots of the parameters of their respective orbits; therefore, the ratio of the parameters of cometary orbits to those of planetary orbits will be much greater than the ratio of the areas described by comets to the areas described by planets in unit time. Whence it follows that, in general, cometary orbits will have enormous dimensions in every direction, and that bodies which describe them will remain perpetually invisible to us, in consequence of their enormous distance. Nevertheless, among the infinite combinations possible in cometary orbits, there are two which may bring the cometary cloud within our ken: one, when the comet is moving directly towards the sun, describing a hyperbolic orbit very little different from a right line; and the other, when the relative movement of the comet and sun is almost zero, that is, when the two bodies are moving through the stellar space along parallel lines with nearly equal velocities.

Schiaparelli then goes on to show that when these cosmic clouds are attracted by the centre of our system, the constituent particles of the cloud must be drawn out into a parabolic current; thus, for instance, supposing a cosmic cloud equal in volume to the sun and at such a distance that its apparent diameter is 1′, the sun's attraction upon this would result in the formation of a parabolic chain or stream of such a length that it would require 636 years to pass through perihelion. When the centre was close to the sun, the beginning and the end of it would be distant from it 263 times the earth's distance from the

[1] *Les Mondes*, vol. xiii. p. 147.

sun. There are nebulæ of which the apparent diameter is greater than that of the sun. If we assume such a nebula, with the sun's apparent diameter, 1924″, it would be transformed into a parabolic chain which would require 20,000 years to pass perihelion, its transversal dimension still being such that the earth could traverse it in one or two days at the most. In this way, then, Schiaparelli shows not only that external swarms can be attracted from external space into our system, but that when so drawn out their constituent particles must take the form which we know such swarms as that of November to possess.

More recently this subject has been treated by Prof. H. A. Newton, and some results at which he arrived have been thus stated by Prof. A. S. Herschel :—[1]

"The evidence so strongly and distinctly shown in favour of the theory of the original motion of most, if not of all, of our recorded comets in spaces far external to the solar nebula, rests upon the assumption that the comet-yielding matter of the primitive nebula, if it existed, was confined, like that which formed the planets, to the neighbourhood of the ecliptic plane. This ground for the conclusion may admit of an exception that a similar distribution of the inclinations of the orbits to that which Laplace's hypothesis requires, would have been produced were this matter otherwise spread uniformly on a very distant sphere, instead of in the distant portions of a disk or annulus. But the plane of the planetary motions in the solar system, and the analogy which they present to spiral and disk-like nebulæ in the heavens, scarcely allows us to assume with reasonable probability such a different disposition of the matter of the outer part of the nebula from what the courses of the planets show us must have been its original mode of distribution and of gradual contraction near the centre ; and with no evidence before us of the past or present existence of a distant spherical envelope of nebular matter inclosing the solar system, we may certainly prefer to accept, with Prof. Newton, the much simpler conclusion to which he is finally conducted by his well-executed labours, that, with the exception of a few, perhaps, of the zodiacal comets, and comets of the shortest periods, all the comets which have been recorded are originally denizens of the interstellar spaces, pursuing unknown orbits like the stars, and separated at least and dissevered in their primitive astronomical relations from any connection with the nebular matter which, in the process of concentration supposed by the nebular hypothesis, formed the sun, the planets, and the asteroids."

Most Comets have once existed as External Nebulæ.

We now come to an important question : we have noted the extreme probability that the comets which now form part of the solar system did not always belong to it, but that they were drawn into it by the sun's attractive energy in its course through regions of space which contained the meteorites of which they are composed.

Then, instead of considering the case of a cloud of meteorites at a great distance from the sun, we have to consider one moving in an orbit round it ; and we must attempt to inquire into the conditions of that cloud, both before and after it began to fall under the sun's attraction. Into what conditions must we inquire in order to compare comets with external swarms ? They are mainly these—

(1) It is agreed that a comet is a swarm of meteorites, each meteorite being on an average far from its neighbours. This follows from an inquiry into the masses of comets. These are very small, for they have never been known to appreciably disturb any of the planets, or even the satellites, by their gravitational attraction.

In 1776, Jupiter and his satellites were entangled in a comet, yet the satellites pursued their courses as if the comet had no existence. The comet itself, however, was thrown entirely out of its course by the gravitational influence of the enormous mass of Jupiter, and its time of revolution changed from a long period to a short one of twenty years or so.

Biela's comet, first seen in 1826, appeared as a double comet in 1845. The extreme lightness of the two portions was shown by the fact that their mutual attraction was imperceptible, and each performed its revolution independently of the other.

The mass of a comet probably never exceeds 1/5000 of that of our globe. The meteorites composing them must therefore be very far apart, seeing that this small mass is distributed through spaces millions of miles in extent.

[1] *Monthly Notices*, vol. xxxix. p. 279.

(2) We next assume that a comet's luminosity is to a large extent produced by collisions of meteorites.

It is certain that one of the principal causes of the increase of temperature of a comet during its approach to perihelion is the increased number of collisions due to the greater tidal action which takes place. Hence the larger the swarm, the greater the difference between the attractions of the sun upon opposite sides of it, and therefore the greater the disturbance set up. Also, the shorter the perihelion distance, the greater fraction of it is the diameter of the swarm, and the greater therefore the differential attraction.

The initial movements of the individual members of the swarm, and these superadded by tidal action, may be defined as producing *internal* work.

If all the heat of a comet is produced by such internal work, it is clear that the temperature of the comet will depend (1) upon the velocity of orbital motion of the particles, (2) upon the size of the swarm of which it is composed, and (3) upon its perihelion distance. It will practically be independent of the velocity of the comet in its orbit round the sun.

If the luminosity be due entirely to internal collisions brought about by the increase of solar action, then large comets, or those best visible, should begin to be brilliant long before smaller or more distant ones. But this does not seem to be so. Mr. Hind has pointed out that proximity to the earth is not so important a condition for visibility of a comet in the daytime as close approach to the sun (Nature, vol. x. p. 286); and M. Faye is the authority for the statement that no comet has been seen beyond the orbit of Jupiter (*ibid.* p. 228). "It is assuredly not on account of their smallness that they thus escape our notice in regions where the most distant planets, Saturn, Uranus, and Neptune, shine so clearly with the light which they borrow from the sun ; this is because the rare and nebulous matter of comets reflects much less light than the solid and compact surfaces of the planets of which we speak, much less even than the smallest cloud of our atmosphere."

On the latter part of this quotation it may be remarked that it is not necessary to assume that comets at a great distance from the sun, any more than nebulæ, are visible by means of reflected light.

Another possible cause is that of collisions with bodies external to the comet. If external work is done on a comet by meteorites in space—that is to say, if there are collisions with external bodies—the velocity of the comet must be considered in the first place, and the equal or unequal distribution of the masses which it encounters can be tested by the phenomena observed.

The discussion of the recorded observations shows, indeed, that in addition to the constantly increasing action which takes place in a comet during its approach to perihelion passage, there are at times temporary increases in temperature.

We know that meteorites are scattered through space, and here and there are gathered into swarms. It is only to be expected, therefore, that at times a comet will meet with such swarms just as our own planet does, and in that case its temperature would be increased by the collisions which would occur. The increase of temperature would depend upon (1) the dimensions and density of the swarm ; and (2) upon its velocity. The larger and denser the swarm the more collisions would be likely to occur, and the greater the velocity of the comet, the greater the amount of kinetic energy available for transformation into heat energy.

If we assume that the increased brightness of comets as the sun is approached depends to any extent on collisions with meteorites external to the swarm, we must conclude that such meteorites exist nearer together nearer the sun. This we should expect. A test of this view would be great and irregular variations of intensity, as we know that the meteorites which the comet is liable to meet are not equally distributed. Such a variation was noticed in Sawerthal's comet in 1888, amounting to three magnitudes (Nature, vol. xxxviii. p. 258) in two days.

Such variations, however, would be more likely to be observed in the tails in consequence of the enormous dimensions of some of them ; and indeed they have been observed from the time of Kepler.

The fact that these variations so strongly resemble at times auroral displays is an additional argument in favour of the meteoric origin of the latter.

Another result of a different order produced by a comet moving through a meteoric plenum would be the gradual shortening of a comet's periodic time, and this shortening should not be absolutely regular, as in a homogeneous gas, for the reason that the meteorites are not equally distributed.

That there is such a shortening was proved by Encke for the comet which bears his name, as the following table will show:—

Returns of Encke's Comet, showing Reduced Period of Revolution.

	Observed Period of Revolution. days. h. m.	Difference. h. m.
From 1786 to 1795 three times........	1212 15 7	
,, 1795 ,, 1805 ,, ,, ...	1212 12 0	3 7
,, 1805 ,, 1819 four ,, ...	1212 0 29	11 31
,, 1819 ,, 1822	1211 15 50	8 39
,, 1822 ,, 1825	1211 13 12	2 38
,, 1825 ,, 1829	1211 10 34	2 38
,, 1829 ,, 1832	1211 7 41	2 53
,, 1832 ,, 1835	1211 5 17	2 24
,, 1835 ,, 1838	1211 2 38	2 39
,, 1838 ,, 1842	1210 23 31	3 7
,, 1842 ,, 1845	1210 21 7	2 24
,, 1845 ,, 1848	1210 18 29	2 38
,, 1848 ,, 1852	1210 17 2	1 27
,, 1852 ,, 1855	1210 11 17	5 45
,, 1855 ,, 1858	1209 13 41	21 36

Here, then, we have three possible sources of collisions. In any case, if any light be produced by collisions, we have the spectroscope as a sure guide to enable us to determine its chemical origin.

We have already seen that the telescopic appearance of a comet when far away from the sun and when close to it are very different. We must now introduce the verdict of the spectroscope. It was observed by Dr. Huggins in the comets of 1866 and 1867 that when they were very far away from the sun the spectrum consisted chiefly of a line seen in the spectrum of those nebulæ which he had up to that time examined. Unless, then, Dr. Huggins has withdrawn this observation, there is a *spectroscopic* connection between nebulæ and comets away from the sun.

The phenomena of comets revealed by the telescope show, as we have seen, that as a matter of fact a good many of them seem to be connected in some way or other with the production of luminous concentric or eccentric envelopes.

In the case of a comet gradually getting nearer the sun, and getting very excited as it gets there, we pass from the spectrum already described to a very different one. There is a considerable change similar to that observed in experiments with meteorites, the spectrum of carbon produced from some compound of carbon or another. In nineteen cases out of twenty when the comet gets near the sun and near enough to the earth for us to have a good look at it, the spectrum is a spectrum of carbon.

On its first appearance in a cometary spectrum, carbon is represented by the flutings which are special to low temperatures. In the most visible part of the spectrum these flutings differ very little in position from those which appear at a higher temperature, but in the blue there is a low-temperature fluting about wave-length 483, whilst the nearest high-temperature fluting is 474. If, therefore, this fluting be observed, the presence of cool carbon may be safely inferred, although it would not be quite safe to infer its presence from observations of the green flutings. This has certainly been observed in two comets—namely, Winnecke's comet (1868) on June 17 (the perihelion passage occurring on June 24), and in Brorsen's comet (1879) on March 25 (the perihelion passage occurring on March 30). The limited number of recorded appearances of cool carbon in comets is doubtless due to the same cause as in the case of the line near λ 500, which Dr. Huggins ascribed to an unknown form of nitrogen, while I ascribe it to magnesium, since we know that there is magnesium in meteorites, and we do not know that there is an unknown form of nitrogen. The reason is that the temperature being low, the light is excessively feeble and observations therefore difficult. When nearer perihelion passage, the comets get hotter, and the spectrum of cool carbon is replaced by that of hot carbon. Under these conditions of increased temperature, comets lend themselves best to spectroscopic study, and hence it happens that in the majority of cases the spectrum of a comet (if the temperature be increasing) has not been observed until it has arrived at this stage.

Manganese is the next substance which writes its record in the spectroscope. It is first represented by a fluting at 558,[1] which is the brightest fluting in its spectrum at a low temperature. This fluting is very persistent, and becomes visible even when there is only a very small percentage of manganese present in the substance examined. The fluting is always seen before the iron lines in the spectrum of ordinary iron at the temperature of the oxyhydrogen flame, and this is the case even with the purest specimens of electrolytic iron which has yet been prepared. The effect of the addition of this fluting to the spectrum of carbon is to modify the appearance of the citron band in the cometary spectrum in a very definite manner.

At a still higher temperature, the radiation of lead is added to that of manganese and carbon, which still further modifies the appearance of the citron band. The brightest lead fluting is at wave-length 546, and when this is present in the spectrum of a comet the citron band has three maxima of brightness, one at 564 (carbon), one at 558 (manganese), and one at 546 (lead).

Afterwards, the temperature having increased, the radiations of manganese and lead give way to the absorption flutings of these substances, carbon radiation from the interspaces still remaining. The result is again a very definite modification of the appearance of the citron cometary band, the general effect being an apparent shifting of the carbon fluting from wave-length 564 to a more refrangible part of the spectrum—namely, to 558, when only manganese absorption is added, and to 546 when both manganese and lead absorptions are added.

Until quite recently, the variations in the position of the citron band in different comets, or in the same comet at different periods, have been attributed to faulty observations, it being supposed that carbon pure and simple was in question. It is now certain, however, that this is not so in all cases. The variations are real, and are simply dependent upon the temperature, or indirectly upon the distance from perihelion.

In some cases iron fluting absorption has also been observed under these conditions of high temperature.

The spectral conditions brought about in the comets which in our time have got nearest to the sun were very similar to those observed in the electric arc, and the recorded observations of the spectrum show that we were dealing with a considerable number of lines of iron, manganese, and other substances.

We see in the telescope that a comet puts on the appearance of a central nucleus with surrounding envelopes or jets, so that we must understand that in the spectroscope the spectrum of the nucleus is seen distinct from the spectrum of the envelopes and jets, because the former is made to fall upon one part of the slit of the spectroscope and the latter upon another.

When a comet approaches very near to the sun we get in addition to the usual flutings of carbon, bright lines, *especially in the spectrum of the nucleus*, so that in addition to the long flutings of carbon as visible in the spectroscope we have short lines added along the nucleus in the red, yellow, green, and so on.

In those comets which have reached a very high temperature, like Comet Wells and the Great Comet of 1882, there is evidence of line absorption. At the same time there were bright lines, proceeding from the incandescent vapours driven away from the meteoritic nuclei by the solar repulsion. Without this repulsion, it is highly probable that there would be line absorption pure and simple, and this has to be taken into account in comparing the spectra of comets with the spectra of other meteor-swarms.

During the passage of a comet from perihelion to aphelion, the temperature decreasing, these changes take place in inverse order.

In spectral phenomena, then, we have another term of comparison to apply, and it may be stated that the sequence of spectral changes are now known to us in a very definite way, so that the chemical changes which take place in the composition of the vapours of comets produced by collisions at various distances from the sun have been ascertained.

Whether we take form, distance apart of component parts, or spectrum, there is now ample proof that the external bodies which supply us with these shreds and patches which we term comets are the nebulæ.

It has already been stated that if we can rely upon Dr. Huggins's observations, in some comets at aphelion and in some planetary nebulæ we get a single line at the same wave-length, so that from

[1] Students of spectrum analysis will understand that this is a "short title," and does not represent the *exact* wave-length, which with adequate instruments might require something between 10 and 100 numerals.

this observation alone it would seem extremely probable that when a comet enters our system for the first time it simply means that a swarm of meteorites in that part of space through which the sun was passing at the time began to feel the sun's attraction, and ultimately became a member of our system, and also that when we see the appearance which we call a nebula in space, since its spectrum is the same as the spectrum of a comet, the nebula is simply a swarm of meteorites if it be true that a comet is a swarm of meteorites.

These nebulous masses, visible in all parts of the heavens, but in some parts of the heavens very much more numerously than in others, were very early observed and imagined to be very different in nature from the so-called fixed stars.

Ptolemy was the first to point out, when he was making his map of the stars that there were certain "cloudy" stars of which he gave 5 on his map, and Tycho Brahé, whose work was done before the invention of the telescope, although he did not notice any bodies which we now class as nebulæ, was firmly convinced that that nebulous luminosity, which we call the Milky Way, was something entirely different in its nature from the stars. He imagined it to be what he called an ethereal essence, a sort of fire mist, so that when in his time, in the year 1572, a new star appeared, he supposed it to be a considerable agglomeration of this ethereal fluid. Galileo was able to show that the Milky Way, the "ethereal substance" of Tycho, was only an appearance due to enormous numbers of stars lying in the same visual ray, the stars of which the Milky Way is composed can indeed be seen with very small optical power. It was not till 1612, a few years after the introduction of the telescope, that we got the first real definition of a body which we now call a nebula.

The first observation we owe to Simon Marius, who stated that some of the bodies visible exactly resembled the appearance produced by the flame of a candle seen through horn. It was not till 1656 that the nebula in Orion was discovered, although now to the trained eye it is very easily visible, so that it seems rather wonderful that it was not discovered before. In 1714, in England, attention began to by paid to these bodies, but it was not until the time of Sir Wm. Herschel that the most magnificent revelations were made. He was the first to construct very large telescopes, the function of very large telescopes being to collect light, so that objects which appear to the eye as excessively dim may be brought into full visibility.

After not only Sir Wm. Herschel but his son, Sir John Herschel, had accumulated vast stores of facts, Lord Rosse took up the story, and made a telescope very much more powerful than any which had been employed by the Herschels. His telescope has a light-grasping power compared with the eye of 130,000. One of the results of Lord Rosse's work to which we need here refer is the idea that in a great many bodies which had been classed as nebulæ this enormous increase of optical power suggested that we were only dealing with very distant clusters of stars.

Lord Rosse was able to get the suggestion of "resolvability" in so many bodies which had been classed as nebulæ by Sir Wm. Herschel and others, that gradually the idea came to be held that the most nebulous nebula, if we could get sufficient optical power to bear upon it, would be broken up into stars, just as certainly as the Milky Way had been.

This would mean that the nebulæ were simply clusters of stars so infinitely remote from our ken that even with the power of Lord Rosse's instrument they put on the appearance of an ethereal essence.

This was the general opinion in 1864, in the early days of spectrum analysis, when Dr. Huggins turned his spectroscope one night to one of the planetary nebulæ. At first he thought that something had gone wrong in the apparatus because he could only see a bright line instead of the usual sort of spectrum obtained from a star. The spectroscope, however, was doing its level best, and the cause, the anomaly, was really that the nebula gave out monochromatic light.

In some cases another line was seen, stated to be due to hydrogen. It now appears that the dispersion employed was so small that the discoverer had no right to allocate any line, so that it is fortunate that other observers have since shown that there is another hydrogen line visible.

Dr. Huggins came to the conclusion that the first line was very nearly, if not exactly, in the position of the chief line seen in the spectrum of nitrogen, and the suggestion was therefore made that these nebulæ were masses of nitrogen and hydrogen gases mixed, or, if not nitrogen, some constituent of nitrogen mixed with hydrogen. That result made the idea of Lord Rosse concerning the possibility of the resolvability of nebulæ into stars untenable. We had to consider from that time that the light of the nebulæ came from a gas, and hence it was held that the nebulæ were masses of gas.

Another explanation of the origin of the green line has already been given. If we study the spectrum of magnesium we find a very bright fluting with its less refrangible edge absolutely in the position of the green line with the dispersion generally employed; in nebulæ and in comets the same line appears, if, as I said before, Dr. Huggins's observations are to be relied upon.

We are therefore justified in holding the view that nebulæ, like the comets, consist of meteorites.

J. NORMAN LOCKYER.

(To be continued.)

THE ANNUAL VISITATION OF THE GREENWICH OBSERVATORY.

THE Report of the Astronomer-Royal to the Board of Visitors of the Royal Observatory, Greenwich, was received at the annual visitation on Saturday last, June 1.

As regards buildings, it is noted that the new 18-foot dome is completed, together with the photographic dark rooms, in preparation for work with the 13-inch photographic equatorial which is to be erected this year. As regards transit-circle observations, we read:—

"The regular subjects of observation with the transit-circle are the sun, moon, planets, and fundamental stars, with other stars from a working catalogue, which includes all the stars in Groombridge's Catalogue and in the Harvard Photometry not observed since 1867, and a selection from Piazzi's Catalogue. Ten close circumpolar stars taken from the *Connaissance des Temps*, or from M. Lœwy's list of stars for longitude determinations, have been observed regularly, in addition to the four standard azimuth stars. The observation of these close circumpolars has been much facilitated by the adoption (since 1889 January 1) of the method used by the officers of the French Service Géographique, which consists in making a number of bisections of the star with the R.A. micrometer during its transit, the exact time for each bisection being recorded on the chronograph. The Annual Catalogue of stars observed in 1888 contains about 1820 stars.

"Special attention has been given to the observation of the minor planet Iris and comparison stars in connection with the determination of its parallax at the late favourable opposition, eighteen observations of the planet and 113 of twenty-eight comparison stars having been made last autumn."

As regards computations, the transits have been completely reduced so as to exhibit mean Right Ascension 1889 January 1, and also the circle observations to exhibit mean North Polar distance for the same period. Two determinations of the astronomical flexure of the transit-circle telescope have been made since the last Report, the resulting values being 0"·08 and 0"·52. It has been found that the correction for discordance between reflection and direct observations of stars was erroneously applied in 1887, and hence the results for colatitude and for position of the ecliptic are also erroneous. The correct values are now given, with those recently found for 1888.

The ecliptic investigations from 1877 to 1886 have been revised to reduce the results to the same system of flexure, R—D correction, refraction and colatitude; so the computations for the ten-year Catalogue, containing 40,000 observations of 4059 stars, are now practically complete.

It has been found that the mean error of the moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) is + 0·090s. in R.A., and + 1"·21 in longitude, as deduced from seventy-four meridian observations in 1888. The mean error in tabular N.P.D. is − 1"·19, indicating that the mean of the observed N.P.D.'s is too great. A number of altazimuth observations has been made and reduced to April 8, so as to exhibit errors of moon's tabular R.A., N.P.D., longitude, and E.N.P.D.

The object-glass for the new 28-inch refractor is now being worked, and, as it is to be of a special form, equally suitable for photographic and eye observations, an experimental object-glass is being mounted on the Sheepshanks equatorial for trial. A number of photographs of stars have been taken with the experimental 6-inch object-glass, supplied as a preliminary to the construction of the 13-inch, which is to take part in the construction of the photographic map of the heavens. Only inconclusive results have, however, as yet been obtained. The spectroscopic work has mainly consisted of observations of motion of stars in line of sight. We read :—

"For determination of motions of approach or recession of stars, 236 measures have been made of the displacement of the F line in the spectra of 38 stars, and 18 of the *b* line in the spectra of 8 stars, besides 5 of the *b* line in the spectrum of Saturn's ring, and comparisons with the spectra of the moon, Venus, the sun, or the sky, as a check on the general accuracy of the results. Observations of Algol on three nights during the past year confirm the previous results indicating orbital motion, but further evidence is required to establish the fact. The spectra of γ Cassiopeiæ, *o* Ceti, β Lyræ, P Cygni, R Cygni, and β Pegasi, have been examined on several occasions, and Comet *e* 1888 has been spectroscopically observed on one night, the spectrum being chiefly continuous. The spectroscopic observations of all kinds are completely reduced."

Photographs of the sun have been taken 182 days in the year ending on May 10, 1889. Indian and Mauritius sun photographs have been received from the Solar Physics Committee as far as 1888 December 31 and December 9 respectively, and it is noted that, by means of photographs from these two places supplementing the Greenwich series, the daily photographic record of the sun's surface is practically complete since the beginning of 1882. For earlier years 118 photographs of the sun taken at Harvard College, Cambridge, U.S.A., between 1874 December 9 and 1875 December 31, and ten photographs taken at Ely, between January 1 and February 25, 1874, have been received from the Solar Physics Committee.

The photographs of the sun for 1888 show that it has been free from spots on 155 days in the year 1888, the longest spotless periods being February 4 to 17, May 24 to June 8, and October 5 to 25. The mean spotted area in 1888 was half that of the preceding year, and corresponded closely to that for 1877, so that the minimum may be expected to occur during the present year. The mean distance of spots from the equator has also diminished to 7°·38 in 1888, being very little larger than it was in 1878, just before the last minimum, and this is a further indication that the sun-spot minimum is close at hand. The faculæ in 1888 show a diminution in correspondence with that of sun-spots, their area for 1888 being intermediate between those for 1876 and 1877.

Continuous observations of the changes in the three magnetic elements of declination, horizontal force, and vertical force have been photographically recorded.

The following are the principal results for the magnetic elements for 1888 :—

Approximate mean declination	17° 40′ W.
Mean horizontal force ...	3·9480 (in British units). 1·8204 (in Metric units).
Mean dip	67° 24′ 26″ (by 9-inch needles). 67° 25′ 33″ (by 6-inch needles). 67° 26′ 16″ (by 3-inch needles).

In the year 1888 there were only three days of great magnetic disturbance, but there were also about twenty other days of lesser disturbance, for which tracings of the photographic curves will be published, as well as tracings of the registers on four typical quiet days.

The meteorological results are as follows :—

"The mean temperature of the year 1888 was 47°·7, being 1°·6 below the average of the preceding forty-seven years. The highest air temperature in the shade was 87°·7 on August 10, and the lowest 18°·4 on February 2. The mean monthly temperature in 1888 was below the average in all months excepting May, November, and December. In March, April, July, and October it was below the average by 3°·6, 3°·6, 4°·4, and 3°·9 respectively, and in November it was 4°·0 above the average.

"The mean daily motion of the air in 1888 was 296 miles, being 12 miles above the average of the preceding twenty-one years. The greatest daily motion was 790 miles on March 11, and the least 57 miles on December 31. The only recorded pressures exceeding 20 lbs. on the square foot were 31 lbs. on March 11, and 21 lbs. on August 28.

"During the year 1888 Osler's anemometer showed an excess of about nineteen revolutions of the vane in the positive direction north, east, south, west, north, excluding the turnings which are evidently accidental.

"The number of hours of bright sunshine recorded during 1888 by the Campbell-Stokes sunshine instrument was 1068, which is about 250 hours below the average of the preceding eleven years, after making allowance for difference of the indications with the Campbell and Campbell-Stokes instruments respectively, and it is 333 hours below that of 1887 recorded with the same instrument. The aggregate number of hours during which the sun was above the horizon was 4465, so that the mean proportion of sunshine for the year was 0·239, constant sunshine being represented by 1. A comparison has been made of the records of the Campbell and Campbell-Stokes instruments for the twelve months from 1886 June 1 to 1887 May 31, with the result that the former registered 1256 hours of bright sunshine, while the latter registered 1364. It would appear, therefore, that the indications of the former instrument require to be multiplied by the factor 1·086 to make them comparable with those of the latter.

"The rainfall in 1888 was 27·5 inches, being 2·9 inches above the average of the preceding forty-seven years."

The average daily number of chronometers and deck watches being rated is 212, and the total number received up to May 10, 1889, was 668. The Astronomer-Royal notes that in future the duration of the trial of deck watches will be increased from twelve to sixteen weeks, viz. six weeks in the ordinary temperature of the room, four weeks in the oven (temperature 80° to 85°), and finally six weeks in the room.

The Report concluded with a note on the re-determination of the difference of longitude between Greenwich and Paris :—

"Observations were made in four groups of three nights each (or the equivalent in half nights). An English and a French observer were stationed at each end, each with a separate instrument and chronograph, and the pairs of observers were interchanged twice, to eliminate any change in the personal equations during the progress of the work. The pairs of English and French instruments were similar, and the signals as well as the star transits were recorded on similar chronographs. On a full night each observer recorded about forty star transits, reversing his instrument three times, and exchanged signals twice (near the beginning and end of the evening) with his compatriot at the other end of the line, and once with the other observer. At Greenwich the transits were referred to the sidereal standard clock, and comparisons with the large Greenwich chronograph enable the ordinary determinations of clock-error with the transit-circle to be utilized as well as those specially made with the portable transits. With this object transits of clock stars with the transit-circle were usually taken by four observers on each night during the longitude operations. The actual stations were the Front Court of the Royal Observatory and the Observatory of the Service Géographique de l'Armée at Paris, the position of which reference to the Paris Observatory has been accurately determined. Commandants Bassot and Defforges were the French observers, and Mr. Turner and Mr. Lewis the English. The observations lasted from September 23 to November 15, and 18 nights of observation at both stations are available, the two English observers having observed at Greenwich 653 transits of clock stars and 165 of azimuth stars, and at Paris 778 transits of clock stars and 165 of azimuth stars. All of these, as well as the signals exchanged, have been read out from the chronograph registers and the reductions are far advanced. Subsidiary investigations of the value of a revolution of micrometer screw, of intervals of wires, of form of pivots, and of errors of the axis-level have consumed much time, the last-named having been a long and tedious discussion."

The difference in longitude between Greenwich and Dunkerque will be determined this month, and Commandant Defforges also proposes to determine the latitude between these two places.

THE EARTHQUAKE.

ON the evening of Thursday, May 30, a considerable seismic disturbance was noticed over the English Channel and in the neighbouring districts. Its area cannot yet be precisely determined. It seems to have been felt most strongly in the Channel Islands, but it was also very distinctly noticed over wide districts in the south of England and the north of France. We bring together various facts relating to the earthquake, some of which have been communicated to us by correspondents.

In Guernsey four successive vibrations were felt at 8.15 p.m. It is said that the houses in St. Peter-Port trembled for several seconds, and that most of the occupants rushed into the streets. The weather had been very sultry for some hours previously.

The shock was felt not less severely in Jersey, as the two following letters will show. The first, which has been sent to us from the Meteorological Office, is by the correspondent of that Office at Jersey, and is dated St. Aubin's, May 31:—"Last evening, at 8.15 p.m., there was a rather severe shock of earthquake here; in fact, it visited the greater part of the island, as far as I can learn. But what I heard myself was a loud rumbling noise, and everything began to shake and tremble, even the buildings; it so frightened a great many that they ran out of their houses, not knowing what was the matter. It appeared to me to travel from north to south, and lasted for about two to three minutes. The barometer at the time was steady, the wind south-south-west, force 4, and a fine night with a clear starlit sky; this morning the weather was gloomy. There was a mock sun, and afterwards a solar halo, but it has been a fine day, with a deal of cirro clouds moving from a southerly direction and looking very heavy in the westward all day, and at present we have cold nights." The second letter has been sent to us by the Rev. W. Clement Ley, to whom it was written, on May 30, by a friend at St. Helier's, Jersey:—"A series of earthquake waves passed here at 8.14 this evening: I could not be quite sure of the direction, but I think from south-west to north-east. They continued for forty seconds at least. I was in my room at the top of the house, and so felt the full force. The whole room trembled, windows rattled, and at the same time the room swayed gently. Some one at the time ran along the road shrieking, 'Earthquake! earthquake!' I think that this is the most severe shock that has been felt in Jersey for many years."

At Sark, also, the earthquake was noticed. Major R. D. Gibney, writing to us from that island on May 30, says:—"This evening I felt two distinct shocks of earthquake, the whole lasting about three seconds, the direction being from south to north-west. Time (believed to be Greenwich) 8.25 p.m. The night was clear, but the setting sun and angry clouds hanging on the horizon presaged rough weather. The shock or shocks were sufficiently severe to shake furniture and to rattle crockery on shelves in almost every house in the island. A low rumbling noise, somewhat like distant thunder, accompanied the vibrations."

Three sharp shocks were felt on the same evening at Cherbourg, but the time has not been exactly noted. The cornice of the doorway of the Church of the Holy Trinity was thrown to the ground. The earthquake is said to have been distinctly felt at Havre, Granville, Caen, and Rouen; and it is stated that it was also felt in Paris at certain points on the left bank of the Seine.

Correspondents have written on the subject to NATURE and the daily papers from many different parts of the southern coast of England. A writer at Penzance testifies that three or four shocks were felt there at 8.21, the direction being from west to east. Mr. J. M. Hayward, writing to us from Sidmouth, on May 31, says:—"As I was sitting here alone quietly reading yesterday evening, I felt a very decided shock of earthquake, three distinct vibrations, each of which shook my chair to and fro several times, and made the things on the table—a china plate with a small glass of flowers in it—rattle; the last was strong enough to make me put down my paper, take off my glasses, and wonder whether the room would tip over. I immediately made a note of the time, 8.20, but I cannot answer for my clock being exactly right." At Blandford, Dorset, a vibration, which is said to have occurred at 8.18, lasted about ten seconds; and Mr. G. J. Groves states that the glass and china ornaments in the room in which he was sitting rattled audibly. According to the Rev. L. Lester, a distinct shock was felt at Wareham, Dorset, "about a quarter past 8." "It happened," he says, "while we were in church. There was first of all a very slight shock, which caused the roof to crack, as it does sometimes in a strong gale; but immediately after there was one much more severe, strong enough not only to make the roof-timbers crack in a far greater degree, but also to set the lamps in the chancel swinging. Those of the congregation who happened to be sitting in seats attached to the main piers or pillars of the church felt a distinct movement. The direction of the shocks seemed, by the way in which the noise ran along the roof, to be from north-west to south-east." At Poole the shock was so severe that many persons rushed from their houses in alarm. Colonel L. S. Venner, writing from St. Rode, Bournemouth, says that at 8.20 p.m. a shock of earthquake passed through the house, travelling from south to north. "The features of it were a strong quivering of the floor, with an up and down movement, accompanied by a hollow noise underneath, and the shaking of shutters and crockery. An invalid's bed was a good deal oscillated, and a dog on it was alarmed. The shock was not at all violent. The wind, which was cold and fresh from south, became still just before the shock, and then freshened up again. The sky was clear." Mr. J. Grey, also writing from Bournemouth, fixes the time at 8.18. He and three others were in a ground-floor room facing the sea, when they felt two shocks: it seemed as if the floor was upheaving. The servants at the back part of the house did not notice it. At Portsmouth, Havant, and the surrounding district the shock is said to have been felt about 8.25; and at Havant, where articles were visibly moved, there was "considerable alarm." In many parts of the Isle of Wight the earthquake attracted notice, and at Sandown and Shanklin the residents are said to have been "greatly alarmed." Dr. F. M. Burton, the senior curate of Newport, writes:—"We were in church, attending the evensong of Ascension Day. It was about the middle of the sermon, when a tremor passed through the church, apparently from north to south. The roof groaned and cracked; the reading-desk in which I was seated (a solid old oak structure, of 1636) perceptibly and very unpleasantly moved, and the gas standards shook for some minutes after. Our vicar, the archdeacon of the island, and several members of the choir and congregation observed it. One lady (Mrs. Haigh) had the presence of mind to time the shock, which took place about twenty-three minutes past eight. Several people told me next morning that they felt the shock more or less severely in their houses." Writing from St. Laurence, Ventnor, Mr. W. E. Kilburn says:—"A very distinct shock of earthquake occurred here at 8h. 21m. 30s. p.m. The shock was not sufficient to overthrow anything or to stop the clocks; but the long pendulous drops, 8 inches long, of the glass lustres on the solid marble chimney-piece formed admirable seismometers, vibrating freely for twenty minutes afterwards, and showing the direction apparently from the south-west. The aneroid and barometer indicated 29·73 at the time; they were 29·80 at 9 o'clock in the morning. The temperature in the open air was 53° by Casella thermometer, and the wind south-south-west. The duration of the shock was about three seconds." The Rev. A. Conder says that at Bognor there were two severe shocks at 8.20, with an interval of about three seconds between them:—"An invalid in an adjoining house called for assistance, as some one was under her bed lifting it. I distinctly felt the shocks, which caused the window-frames to rattle." At Littlehampton, at 8.22, cranes were seen to swing suddenly, and an oscillation was felt in different parts of the town. At Arundel, while reading on a sofa, Mr. E. Goldsmith suddenly "felt a peculiar movement, and distinctly saw the sofa vibrate for three or four seconds." "At the same time," he says, "the windows shook, not as they had occasionally done during the evening on account of the wind, but with a quite different and more continuous movement. I called to my daughter, who was at the moment in the dining-room, to know what was the matter; but she had only heard the windows shake in the room where she was (but in the same peculiar manner), and had not felt any movement. My little boy, who was in bed upstairs, felt his bed move; and my two little girls, who were going to bed, were quite frightened, and ran down to know if it was an earthquake. The servant with them felt it too. The time was 8.20." At Brighton a distinct shock was felt, especially in the western part of the town; and at Rudgwick, near Horsham, two persons in a room noticed a movement "which caused a rocking of chairs, cracking of woodwork, and the sound of rumbling, apparently exhausting itself to the westward." Captain H. King, R.N., writes to us from Petersfield:—"On the evening of May 30, at 8.20 p.m., I was leaning upon a spring mattress, when I felt it vibrating in a peculiar manner. We could only account for it by an earthquake; and surely enough the newspaper of next day described one at Guernsey, which appears to have been similar to one which I witnessed in Jersey in April 1853." Mrs. Lane, also writing to us from Petersfield, says that she and her children's governess, while sitting together, "were startled by a most peculiar vibration seeming to shake the house, which quivered perceptibly for some seconds."

Several correspondents of the *Times* testify that they felt the shock in London. Mr. Ernest Myers writes from 31 Inverness Terrace, W.:—"A slight but unmistakable shock was felt here about 8.20 p.m. There was no rattling of windows or other sound. The vibration seemed to be from side to side." Mr. E. W. Haines, of Alexandra Road, St. John's Wood, says:—"The earthquake was distinctly, though slightly, felt here last evening at 8.30." A member of the firm of Yates, Crighton, and Co., of Cannon Street, E.C., while working in their offices on Thursday evening, distinctly felt four shocks just before 8.30. He says:—"It was the more noticeable as our offices are situated in a huge building, on the third floor, and the sensation was just as if the whole block were rocked by the wind from south to north." "C. W. H." writes from the General Post Office:—"Last evening I was sitting in my room, situated in the south-west corner, top story of the General Post Office, when I felt my chair oscillate with a slight tremulous motion, which lasted perhaps four seconds. Thinking it was a slight shock of earthquake, I stood up, and looking at my watch saw the time was 8.20." A person living at West Kensington reports having felt the shock at 8.15. Mr. F. Yates, writing from Park Street, Southwark, S.E., May 31, says:—"Yesterday evening, between 8.20 and 8.25, while sitting in my library at Surbiton, I distinctly felt two light shocks, which I attributed to earthquake. The shocks were also observed by other members of my family."

Mr. J. Lloyd Bozward writes to us from Henwick, Worcester, that the earthquake was perceptible there. While seated in a room on the second floor of his house at about 8.23 p.m. on Thursday, all being still, he felt five distinct tremors in rapid succession, the third being the most notable. "On making immediate inquiries," he says, "I learned that the tremors had not been felt on the other floors, but my son, who happened to be in the basement on the occasion, says that at the time referred to by me he noticed that the flame of a lamp burning on the table suddenly shot up above the top of the glass chimney."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Annual Report of the Museums and Lecture Rooms Syndicate, just issued, contains much interesting information about the progress of natural science studies and collections.

Prof. Babington announces that the late Prof. Churchill Babington's extensive herbarium has been presented to the Botanical Museum by his widow, including the typical specimens of lichens described by him. The type collection has been enlarged. and demonstrations in organography and histology are regularly given. Mr. Potter has just returned from Ceylon with a fine collection. A series of germinating seedlings (prepared by Mr. Barber), specimens showing the injuries caused to plants by insects (by Mr. Shipley), and Kny's diagrams, given by Mr. Thiselton Dyer, are among the valuable acquisitions.

Mr. J. W. Clark, Superintendent of the Museum of Comparative Anatomy, reports the gift of a beautiful collection of spiders, with accompanying drawings, by Mr. Warburton; the mounting of the skeleton of *Rhytina gigas*; the deposit of a valuable collection of skulls and bones of Bovidæ and Cervidæ, by Mrs. Stewart, widow of Surgeon-General L. C. Stewart; Surgeon-General Day has given 357 birdskins from India and Burmah; and Messrs. Cordeaux have given over 100 valuable Indian specimens.

Two parts of the "Morphological Studies" have been issued by Mr. Sedgwick since the last Report. The Elementary Biology Class numbered 167 in the Easter term of 1888, and 139 in the Lent term of 1889. The Morphology Class varied from 77 to 42; with a smaller advanced class.

Prof. Macalister reports the addition of 131 Egyptian skulls, 25 skulls from the Saxon burial-place at Hauxton, and many from that behind St. John's College. The Rev. J. Sanborn, of Lockport, N.Y., has given valuable skulls from a burying-place of the Seneca Indians.

Prof. Roy describes the careful and systematic arrangement he has adopted in his Pathological Laboratory (late the Chemical Laboratory).

Prof. Hughes once more deplores the long postponement of the new Geological Museum. It certainly is not just to allow the donors of the funds to die out and never see the erection of the Museum towards which they contributed such large sums. Important additions have been made to the Cambrian and Silurian fossils by Mr. Marr, and many of them have been described and figured by him. Thirty-four figured types from the Inferior Oolite of Dorsetshire have been presented by the Rev. G. F. Whidborne. About 130 slides have been added to the cabinet of microscopical preparations of rocks. Much progress has been made in palæobotany, and two courses of lectures have been given by the lecturer, Mr. Seward. Mr. Strickland's collection of fossils, numbering 7000 specimens, has been presented by the late Mrs. Strickland.

The new Chemical Laboratory proves to be very satisfactory in working.

The demonstrations in the Cavendish Laboratory were attended by 136 students last Michaelmas term and 144 in the Lent term. Twelve persons have been doing original work in the Laboratory during the year. Some important new apparatus has been acquired.

SCIENTIFIC SERIALS.

Mémoires de là Société d'Anthropologie de Paris, série ii., tome iv., fasc. 1 (Paris, 1889).—Pre-Columbian ethnography of Venezuela, by Dr. Marcano. The author prefaces his special ethnographical remarks with a short geographical notice of the Venezuelian territory, entering more particularly into the physiographical character of the fertile valleys of Aragua and Caracas. The special feature of the landscape in these picturesque regions is the range of low hills locally characterized as "Cerritos," which extend over a large area near the beautiful lake of Valencia, first known to the Spaniards as Lake Tacarigua, and which were regarded by the native Indians as natural features of the soil. It has been discovered, however, by recent explorers, that they are artificial elevations, raised in past ages by some aboriginal Indian race long extinct, whose very name is unknown to the present inhabitants of the district, although the shores and bottom of the lake testify, through their vast accumulations of bones and other *débris*, that the country must have been densely populated at some remote prehistoric period. Dr. Marcano, who devoted several years to the exploration of the Cerritos, near Lake Valencia, has succeeded in laying bare the interiors of twenty of these mounds, which prove to be sepulchral caves filled with bone and other detritus. All present a uniform plan of arrangement, and consist of a central circular walled-in space, containing an enormous mass of whole and fractured bones, and marine and fresh-water shells, with fragments of stone, bone, and wood implements, and sherds of pottery, most of which bear traces of the action of fire. The human remains were deposited in round earthen jars or urns, each of which contained only the separate bones of one body, the skull resting at the base of the vessel, while the sacrum, with the long and the small bones, was laid above it so as to fit into all the available space. The appearance of these bones indicates that the flesh had been detached from the dead body before its interment, but their brittle condition rendered a minute examination impossible in some cases, although Dr. Marcano was able to recover forty crania which admitted of sufficiently exact investigation to warrant the conclusion that they represent two distinct types of brachycephalism. About half of these crania showed signs of deformity, due to artificial pressure over the frontal bones. The most remarkable characteristic was their prognathism, which exceeded that of any skull previously examined by him, although his observations were based on the examination of more than 2000 crania, of which some belonged to New Caledonians, who have hitherto ranked as belonging to the most prognathic race extant. The implements found in the Cerritos caves are nearly identical with those associated with the Neolithic age in Europe, while the animal remains are composed of types belonging to the local terrestrial and aqueous faunas, including the broken skull of a cebus; while so enormous a mass of the bones of a caïman (*Crocodilus bava*, which is peculiar to the Lake of Valencia and its affluents) was found, that it is evident the flesh of this animal must have served as food. A number of detailed craniological tables, and numerous illustrations of the crania and of the curious figurines and idols, the urns, tools, ornaments, and other objects interred with the human bones, add greatly to the value of Dr. Marcano's exhaustive memoir.—The superstitions prevalent in Wales, by M. Maricourt. In this article the author has drawn his materials so indiscriminately from casual travelling companions, and from writers of the most various degrees of authority, that his statements can lay no claim to the serious attention of students of folk-lore, and present no interest for the English reader.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, May 25.—Prof. Reinold, President, in the chair.—The following papers were read:—On a relation existing between the density and refraction of gaseous elements and some of their compounds, by Rev. T. Pelham Dale. In a previous communication the author pointed out a relation between the specific refractive energies of sulphur and selenium, and the present paper deals with similar relations in gaseous bodies. On calculating out the values of $\frac{\mu - 1}{d}$ for the elements H, O, N, Cl, S, P, it was noticed that the logarithms were nearly integral multiples of half the logarithm for H, those for N, Cl, and P being double, and S and O three times that number. The value of $\mu - 1$ for different elements is compared with the $\mu - 1$ for H, the resulting numbers being, for oxygen 2, mercury 7, arsenic 8, and sulphur 12 nearly. Similar calculations are made for the compounds N_2O, NO, CO, SO_2, Cy, NH_3, HCl, H_2S, CH_4, and C_2H_4, but as the data obtainable are very rough, the numbers are not so closely integral. The author hopes that better data will be furnished by persons having greater facilities than himself for experimental research. Prof. Rücker thought the results obtained pointed towards some relation between the volumes of the molecules of different elements, and at the close of the meeting announced that on working out the relation he found the relative volumes to be a series of numbers in geometrical progression.—On a water-spray influence machine, by Mr. George Fuller. The apparatus is made up of four similar sections, each consisting of a nozzle, a metal ring, and a metal dish or receiver, arranged about a vertical axis. Pressure-water issues from perforations 1/100 inch in diameter in the nozzles, and passes through the rings into the insulated receivers below. The rings are placed at such a distance below the nozzles as to be about the point where the streams break into spray, and the receivers empty themselves automatically. Calling the consecutive sections 1, 2, 3, 4, respectively, the rings of 1 and 3 are connected to the receiver of 4, and those of 2 and 4 to the receiver of 1. The discharge-points are connected with the receivers 2 and 3, and a rapid succession of sparks passes when the water is turned on. Prof. S. P. Thompson inquired whether the length of the spark was limited by leakage along the glass rods or by the spray passing between the receivers, and in reply Mr. Fuller said he thought the former leakage the most important.—Notes on polarized light: (*a*) on the transition tints of various orders; (*b*) lecture illustrations of the rotation of circularly-polarized light; (*c*) on the rotation of circularly-polarized and non-polarized light, by Prof. S. P. Thompson. The first note described an inquiry as to what thickness of quartz gives the best "sensitive tint" for polarimetric work. Biot gave the name to the tint produced by a quartz 3¾ millimetres thick in a bright field, whereas in most modern polarimeters the name is given to that produced by 7½ millimetres of quartz in a dark field. The transition-tints of various orders were exhibited on a diagram of Newton's scale of colours, and by a wedge of selenite. Experiments were made on quartzes of 3¾ and 11¼ mm., giving tints of the first and second order respectively in the bright field, and with a 7½ mm. quartz in a dark field. The 3¾ was more sensitive than the 11¼ to small rotations, but the 7½ mm. seemed the best of the three. Prismatic analysis of the light transmitted by each led to the same conclusion—a new square-ended direct-vision prism built up of a glass prism (angle 140°) immersed in cinnamic ether being used for that purpose. The author pointed out that the "sensitive tints" of German opticians are decidedly redder than Biot's, and those generally used in England. In the first apparatus devised under (*b*), the ray of light is represented by a stretched cord thrown into promiscuous vibration by a tuning-fork, and the polarizer and analyzer are each represented by two plates of glass mounted parallel to each other about a millimetre apart, between which the cord passes. Between the polarizer and analyzer the vibrations are in one plane, and they are transmitted or cut off by the analyzer according as its plates are parallel or perpendicular to those of the polarizer. By blowing across one side of the spindle-shaped vibrating segment between the crossed plates, the plane of vibration is slightly rotated, and part is transmitted through the analyzer. Other experiments illustrating rotation of the plane of polarization were shown or described, the most conclusive being a bar of heavy glass placed along with a fish-eye lens between crossed Nicols. On starting a current in a helix surrounding the glass, the black cross formed by the fish-lens is seen to turn round as the current grows. Another piece of apparatus to illustrate Fresnel's view of the circularly polarized waves in quartz consists of two equal coplanar disks rotating in opposite directions, and carrying pins on which the extremities of a double pantograph arrangement are pivoted. The middle point of the link-work describes a line perpendicular or inclined to the line of centres of the disks according as the phases of the pins are the same or different. (*c*) In speaking of rotary polarization it is customary to say that the plane of polarization is rotated, but the author thinks it is equally correct to say that the light itself is rotated. Prof. Stefan's and Prof. Abbe's experiments bearing on the subject were described, and to demonstrate that ordinary light may be rotated, a biquartz was placed between a Fresnel biprism and the screen on which the interference fringes were formed. By using quartzes of thickness sufficient to rotate each beam 45°, the interference fringes are caused to disappear, and on inserting a bar of heavy glass in each of the pencils, and magnetizing one of them, the fringes reappear. Mr. Glazebrook thought the reason why 3¾ mm. quartzes were more sensitive than 11¼ might be seen by considering the sector-shaped spectrum in which the rays are spread out by the quartz, for with the thick piece the angle of the sector will be three times that with the thin one, and hence, in the latter case, a greater change of colour is produced by a given small rotation. Mr. Ward strongly condemned the use of biquartzes for rotation measurements, for he found it impossible to get them cut with such accuracy as to give a uniform tint; and if the light be slightly elliptically polarized, considerable error may be introduced. Speaking of magnetic rotation, he thought Fresnel's explanation unsatisfactory, and considered it probable that the rotary character of the magnetic field increases the period of one and decreases that of the other circular wave, their velocities remaining the same. As regards quartz, he believes the rotary action due to the light itself (probably an effect of the longitudinal wave), and not to any peculiar crystalline structure of the quartz, for liquids exhibit similar phenomena. Dr. Thompson, in reply, said Mr. Glazebrook's explanation of the difference in sensibility of the quartzes of various thicknesses was not quite satisfactory, for the reasoning would lead one to expect the 3¾ millimetres to be most sensitive, whereas experiment showed that the 7½ millimetres was best. He quite agreed with Mr. Ward about the defects of the biquartz, and thought the shadow method preferable in many cases. On the other hand, he was disposed to believe that the rotary power of quartz was a result of its crystalline structure, for fused quartz possessed no such property. As regards liquids, Dr. Thompson thought the rotation due to some kind of skew symmetry possessed by the molecules, the average effect of which is observed.—On the molecular weight of caoutchouc and other colloid bodies, by Dr. J. H. Gladstone, F.R.S., and Mr. W. Hibbert. This paper gives the results of determinations made by Raoult's method, the reliability of which was first tested by preliminary experiments on substances of known molecular weights, and found to be fairly satisfactory. The experiments on caoutchouc give a very high value (above 6000), thus confirming the author's previous impression that it was a colloid. Similar experiments were made on gum-arabic, caramel, albumen, and ferric and aluminic hydrates, all of which were found to have high molecular weights. All the experiments confirm the belief that the molecule of a colloidal substance is an aggregate of a very great number of atoms.

EDINBURGH.

Royal Society, May 20.—Sheriff Forbes Irvine, Vice-President, in the chair.—A paper, by Prof. Letts and Mr. R. F. Blake, on the identity of Hofmann's "dibenzyl phosphine" with oxide of tribenzyl-phosphine, and on some other points connected with the phosphorized derivatives of benzyl, was read.—Sir W. Turner communicated a paper by Dr. D. Hepburn, on the development of diarthrodial joints in birds and mammals.—Dr. G. Sims Woodhead communicated observations by Mr. D. McAlpine on the progressive movement of detached ciliated portions of frogs and tortoises, and also observations on the progression, pulsation, and quivering of excised hearts of fish, frogs, reptiles, birds, and mammals.—Dr. John Murray read a paper by Mr. W. S. Anderson, on the solubility of carbonate of lime in fresh and sea water.

PARIS.

Academy of Sciences, May 27.—M. Des Cloizeaux, President, in the chair.—On the radicular nature of the stolons of *Nephrolepis*, by M. A. Trécul. In reply to M. Van Tieghem, the author argues that the so-called stolons of this fossil plant were not shoots or runners, but had the constitution of true roots; hence he was fully justified in describing them as "radicular stolons."—On the representation of the continuous fractions expressing the two roots of a quadratic equation, by Prof. Sylvester. In continuation of his previous paper (May 20), the author shows how the twin formulas there worked out for the two roots x and x' may be considerably simplified and generalized.—On the Calamariæ, *Arthropitus* and *Calamodendron*, by M. Grand'Eury. In this paper the author sums up his reasons for believing that these Carboniferous plants were highly organized Cryptogams. Their representatives or descendants in the Secondary formations were of smaller size, less varied, and more nearly related to *Equisetum*, the last degenerate survivor of the family.—Exact determination of the quantity of water contained in the blood, by MM. Gréhant and Quinquaud. Experiments made on the dog and rabbit show generally that the quantity of water is less in the venous than in the arterial blood. For the dog, the respective proportions were found to be: water, 77·09; dry residuum, 22·91; and 78·01 and 21·99 per cent.—Quantitative analysis of the urea contained in the blood and in the muscles, by the same physiologists. From these experiments, made with the rabbit and the skate, it would appear that the muscles of this fish contain fifty times more urea than those of mammals, and that the urea is formed in the muscles, in which it is present in larger quantity than in the blood.—Distribution in latitude of the solar phenomena during the year 1888, and solar observations for the first quarter of 1889, by M. Tacchini. The results of the observations here tabulated show that in 1888 the solar phenomena were much more frequent in the southern than in the northern hemisphere. The maximum zone for the spots, faculæ, and metallic eruptions lay between 0° and −10°, as in 1886 and 1887. But the maximum for protuberances does not correspond with that for the other phenomena, as it lay in higher latitudes (+30 to +40 and −40 to −50). The observations for the first three months of 1889 show a perceptible diminution of the spots and faculæ as compared with the last quarter of 1888, while the protuberances were somewhat more frequent in the former than in the latter period.—On the expansion of the metals at high temperatures, by M. H. Le Chatelier. In continuation of his previous communication the author here tabulates the results obtained for iron, steel, copper, aluminium, silver, nickel, platinum, and sundry alloys, concluding generally that for all metals the coefficient of expansion increases with the temperature. The law of increase is generally regular except for certain alloys of silver and for all varieties of iron.—Researches on the phenomenon of magnetic rotatory polarization in Iceland spar, by M. Chauvin. In a previous note (April 27, 1886) the author showed, against the opinion of Wertheim, that this substance possesses magnetic rotatory power not only in the direction of the axis but also in the neighbouring directions. His further researches here summarized generally confirm this conclusion, the phenomena observed being identical with those presented by natural quartz.—On the electric conductivity of saline solutions: reciprocal displacements of the acids, by M. P. Chroutschoff. A tabulation of the chief results already obtained of the reactions between salts in solution and acids other than those entering into the composition of the salt under examination.—Researches on the electric resistance of bismuth, by M. Edmond van Aubel. The author here studies the influence of temperature on the electric resistance of bars of bismuth, and examines this metal under two molecular states: melted and slowly cooled; melted and very rapidly cooled or tempered.—On the heat of combustion of some organic bodies, by M. J. Ossipoff. Continuing his determinations of the heat of combustion of organic bodies, the author here deals with racemic acid and its anhydride, and with methyl racemate and tartrate.—On some metallic sulphides, by MM. Armand Gautier and L. Hallopeau. Continuing their last memoir (April 15), the authors here describe the action of carbon disulphide on nickel, chromium, and lead.—Papers were contributed by M. F. Parmentier, on the presence of sulphate of soda in the atmosphere; by M. A. Haller, on a general method of synthesis for the β-acetonic acids of the aromatic series; and by M. E. Sorel, on the rectification of alcohol.—The President announced the death of M. Halphen at Versailles; and M. Hermite paid an eloquent tribute to the memory of the illustrious geometrician at his obsequies on May 23.—The death was also announced of the distinguished physicist and electrician, M. Gaston Planté.

VIENNA.

Imperial Academy of Sciences, March 21.—The following papers were read:—On Van Deen's blood-test and Vitali's pus-test, by E. Bruecke.—On some problems of the theory of the conduction of heat, by T. Stefan.—On the alterations of the pigment in the insect's eye, caused by the influence of light and its physiological meaning, by S. Exner.—New observations on the change of combinations in phenols (third communication), by T. Herzig and S. Zeisel.—On ortho-dicarbonic acids of pyridine, by G. Goldschmidt and H. Strache.

BOOKS, PAMPHLETS, and SERIALS RECEIVED

Petrographical Tables: H. Rosenbusch, translated by F. H. Hatch (Sonnenschein).—An Elementary Treatise on Mechanics: I. Warren (Longmans).—The Metallurgy of Silver: M. Eissler (Lockwood).—A Treatise on Geometrical Conics: A. Cockshott and F. B. Walters (Macmillan).—An Elementary Text-book of Chemistry: W. G. Mixter, 2nd edition (Macmillan).—A Practical Guide to the Climates and Weather of India, Ceylon and Burmah, &c.: H. F. Blanford (Macmillan).—Papers on Alternating Currents of Electricity: T. H. Blakesley, 2nd edition (Whittaker).—A Graduated Course of Natural Science, Part 1, 1st Year's Course: B. Lœwy (Macmillan).—International Annual of Anthony's Photographic Bulletin, vol. ii., 1889-90 (Illiffe).—British Dogs, No. 31: H. Dalziel (U. Gill).—La Période Glaciaire: A Falsan (Paris, Alcan).—Indian Meteorological Memoirs, vol. iii. Parts 3 and 4, and vol. iv. Part 5 (Calcutta).—Report on the Meteorology of India in 1887 (Calcutta).—An Elementary Treatise on Dynamics: B. Williamson and F. A. Tarleton, 2nd edition (Longmans).—Questions on Stewart's Lessons in Elementary Physics: T. H. Core (Macmillan).—The Middle Lias of Northamptonshire: B. Thompson: (Simpkin).—Essays upon Heredity and Kindred Biological Problems: A. Weismann; authorized Translation by Poulton, Schönland, and Shipley (Clarendon Press).—Himmel und Erde, Heft 9 (Berlin, Paetel).—Aus dem Archiv der Deutschen Seewarte, viii. Jahrgang, 1885 (Hamburg).—Observaciones Magnéticas y Meteorológicas del Real Colegio de Belen, 1er Semestre, 1887 (Habana).—Veröffentlichungen aus dem Königlichen Museum für Völkerkunde, i. Band, 1 Heft (Berlin, Spemann).

CONTENTS.

THURSDAY, JUNE 13, 1889.

THE ELEMENTS OF VITAL STATISTICS.

The Elements of Vital Statistics. By A. Newsholme, M.D. (London: Sonnenschein, 1889.)

DR. NEWSHOLME has written a book which, though intended primarily as a guide to medical officers of health and students preparing for the various sanitary examinations, will be found by the general reader to form a convenient compendium of useful facts and of the conclusions deducible therefrom. For the writing of such a book the author was well qualified, having been distinguished as University Scholar in Medicine, and having had, in addition to the ordinary practice of a medical man, considerable experience as a medical officer of health, formerly at Clapham and recently at Brighton. A work of this kind must necessarily consist largely of information derived from the census returns, public registers, and reports; and an author's ability is shown in the selection of the information, its arrangement, and verbal presentation.

Like many persons who have given attention to the subject of vital statistics, whether for sanitary or financial purposes, Dr. Newsholme attaches great value to a correct and more frequent census, and to a complete and accurate registration of births, marriages, and deaths, the cause of death being in all cases carefully ascertained and recorded. He also desires a systematic and extended registration of sickness, its nature and duration; urging that the concurrent publication of information furnished by such registration, and involving the announcement of the outbreak, the spread, and the subsequent contraction of epidemics, would lead to results of the highest public benefit.

The requirements of a good census from a sanitarian's standpoint are said to be that the enumeration shall be accurate and complete—to this we may say, of course—and that it shall be simultaneous throughout the country, in order to avoid the disturbing influences of migration—again, of course. It is suggested that the particulars demanded at the taking of the census should comprise the following items as a minimum: name, sex, age (children under two years stated in months), relation to head of household, conjugal condition, calling, religious persuasion, illiteracy, birthplace and nationality, language, residence, infirmities, this last term meaning, we presume, serious infirmities, such as those of the blind, the deaf, and the dumb, and the several forms of insanity. We ourselves do not see in what way a sanitarian is concerned with the religious persuasions of the people, or with language as apart from and independent of nationality; nor do we think a sanitarian, or any other student or scientific worker, could extract any useful knowledge out of the untested declarations of uneducated persons relative to the ability or inability of themselves and their families to read and write. We do not altogether agree with our author in advocating inquiry on these points; but we entirely agree with him on the remaining points he mentions, to which, in the main, however, the country at large may be considered already to have assented. We would emphasize, with him, the desirability of taking the ages of the youngest children in months; at any rate, for the first year of life. Considering the heavy mortality prevailing during infancy—about one-fifth of all the births being followed by death within two years—and considering its rapid change from month to month, as the development of the infant progresses, it is an obvious requirement of this branch of the subject that steps should be taken to ascertain the mortality for each succeeding month of a child's life, and thus verify the estimates and partial results that have already been published. We would also emphasize, with our author, the desirability that the calling or occupation of each person should be given with sufficient definiteness to obviate confusion. At present one experiences some difficulty in manipulating the figures of the Registrar-General's Office; a difficulty arising not only from the classification of occupation, and partly unavoidable, but also from the inclusion in one figure of masters with workmen, and sometimes of those who have retired from an employment with those actively engaged in it. There is, as is self-evident, the greatest difficulty in obtaining precise information from the millions of an entire population; but the Registrar-General has, no doubt, turned his attention in the directions now indicated with a view to future action.

The Civil Registration Act was passed in 1837, but for a long while the registration of births was defective, it having been estimated that as many as 5 per cent. of the births were lost sight of. This is a fact not to be forgotten in dealing with earlier years. The registration of births was made compulsory by the Births and Deaths Registration Act of 1874; but the record gives neither the age of the mother at the date of the birth of the child, nor the order of its birth (first, second, third, &c.); so that we can know neither the number of children borne by mothers at each year of the mother's age, nor the average number borne in the course of a mother's lifetime. The birth-rate in a community is commonly represented by the ratio of births to population, so many per thousand; but the basis of 1000 living, including, as it does, a varying proportion of men, women, and children, is not a perfect basis; and, to get the true birth-rate, the number of births should be compared with the number of women between the ages of about 16 and 45. The population basis is, as a rule, however, adequate for practical purposes, and tables, so constructed, display, throughout Europe generally, a tendency in the birth-rate to decline. In the United Kingdom the decline has been fairly regular and continuous for some years past, the decline amounting to almost 3 per thousand in seven years.

The chapter on births contains, under the head of "The Malthusian Hypothesis," some remarks respecting the famous essay on the theory of population published in 1798. As popularly understood, the hypothesis was to the effect that the growth of a population must be circumscribed by the means of subsistence. The remarks are especially directed against the doctrine that "the population is increasing in a geometrical progression, the means of subsistence in an arithmetical progression; and unless wars, destructive epidemics, marshes, dense towns, close workshops, and other deadly agents, carry off the excess of the numbers born, . . . the whole people must be exposed to a slow process of starvation." Our author is quite right in attacking this theory, but it is substantially no answer to the theory to say that a geometrical progression may progress so slowly as hardly to progress at all; or that, when the number of births falls below the number of deaths, there is a decreasing geometrical ratio instead of an increasing one. Such an argument is, doubtless, the correct statement of a purely theoretical truth of abstract mathematics, but it does not meet the case as popularly understood. Also inconclusive, in our opinion, are some of the comments on increase of subsistence. To define subsistence as "all that supplies men's wants" is to adopt a definition of the term which calls for definition more loudly than the word defined; and to suggest that we may look to human industry and scientific discovery for the increase of food is to open up before us a very doubtful and probably disappointing prospect. The teachings of Malthus may have been more or less refuted by the history of the present century, but we all agree that the danger of population outrunning subsistence is one that common-sense demands should always be kept in view.

The marriage-rate is usually obtained by comparing the number of marriages with the number of the population in which they occur. This method is exact enough for many purposes, but to attain theoretical accuracy the comparison should be made with the number of eligible bachelors, spinsters, widowers, and widows. Like the birth-rate, the marriage-rate appears to be on the decline, not only in this Kingdom, but also throughout Europe. In England and Wales, bachelors now marry at a mean age of 26·2 years and spinsters at 24·6 years, the age at marriage exhibiting a tendency to increase. The average number of births to a marriage is for England and Wales about 4½; the average for Italy being 5·15; Prussia, 4·92; Austria, 3·73; and France, 3·42. In England and Wales the average duration of ordinary married life has been computed at about 27 years.

It is customary to state the death-rate by comparing the number of deaths with the number living, but the results require to be received with caution. The population of a place may vary in its age and sex composition with the arrival of immigrants and the departure of emigrants; also from an excess or defect of births over or under deaths; also from other and special causes; and these disturbing elements cannot always be left out of consideration. Thus, the general death-rate in England and Wales in 1881 was 18·9, for all ages, while the general death-rate in France was 22·0; but had the age-distribution in France been the same as in England, the French rate would have been 20·9, and it is clearly with this figure, and not with the 22·0, that the English figure is justly to be placed in comparison. With respect to the registration of death, and with a view to obtain better information as to the cause of death, Dr. Newsholme favours the appointment of medical registrars, and thinks the certificate of the medical attendant on the deceased should be withheld from the family and sent direct to the registrar.

To the general reader the discussion of the influence exerted on mortality by climatic and social conditions, by recent sanitary legislation, by density of population, and by occupation, is sure to prove attractive. Figures are adduced to demonstrate that mortality is usually highest in the first quarter of the year and lowest in the third; and we are told that mild winters and cool summers both lower the mortality, the former especially of the old, and the latter of the young. Pervious subsoils apparently afford a better protection against lung-disease and diphtheria than retentive ones, as might naturally be expected; but not so with phthisis, which, according to the figures quoted, is no great respecter of subsoil. As is popularly understood, the death-rates for married persons of both sexes are more favourable than for the single or widowed, but it must not be forgotten that in marrying and giving in marriage a process of natural selection takes place, and that it is only the more or less healthy, if not also the more or less strong, that enter the married state. The aggregation of an ever-increasing proportion of the population in towns has an unfavourable effect on mortality; for the general death-rate in the urban districts, which, according to the mean rates for the country, and making due allowance for age and sex, should have been 20·4, was as high as 23·1, while in the rural districts, where it would have been estimated at 22·83, it was only 19·0. However, the inferiority of town to country, in this respect, is, apparently, becoming less marked. Next to the subject of crowding in towns, comes up for consideration the subject of crowding in houses. Some observations in Glasgow tended to show that among those living in one and two roomed houses the death-rate was 27·74 per 1000; among the occupants of three and four roomed houses, 19·45; and among those living in houses of five rooms and upwards only 11·23; but such results cannot be attributed solely to the extent of house accommodation. The fewer the rooms, as a rule, the poorer the person, and therefore the less able to procure a supply of good and sufficient nourishment, suitable clothing for summer and winter, healthful occupation and recreation, and, in times of sickness, efficient medical attendance and comforts. Of the increased mortality to the poor man, one cannot say what portion is to be ascribed to the narrowness of his habitation, and what portion to the combination of various other and accompanying causes. A whole chapter of the book under notice is devoted to the effect of occupation on the death-rate, but we have not the space to allow of quoting from it. The chapters on the mortality due to each of the seven chief infectious diseases, and to certain other special diseases that flesh is heir to, will prove little less interesting to the reader than those to which we have more fully referred.

Dr. Newsholme is evidently very earnest in his advocacy of the national registration of sickness, *i.e.* sickness of a disabling character. The number of deaths registered as due to a specified disease may or may not give an indication of the prevalence of that disease. The prompt registration of sickness would result in various advantages to the public health. Prophylactic measures could and would be taken to prevent the spread of threatening epidemics; the isolation of patients and suspects would be more generally provided for; the children of an infected family would be debarred from attending school; while the public excitement consequent on any unusual warning given by the registration would lead to the discovery of conditions conducive to disease, to the thorough inspection of houses, workshops, public drains, clothing, and the food and water supplies. Such periods of excitement would have an educational value among parents and householders, and teachers of all kinds, and a better knowledge of sanitary principles would manifest its presence amongst us in a greater freedom from sickness and in an enhanced vigour of mind and body. If the registration of sickness, by informing us, warning us, and alarming us, will compel public attention, and direct it to matters of public health, and enable us to resist our worst and deadliest foes, by all means let us have registration.

When one reflects on the attention given to sanitation for, at least, the last twenty years, and on the labour and money devoted to it since 1872, when the Public Health Act came into operation, one naturally asks what has been the effect on the national death-rate of all the sacrifices we have made. The answer is, on the whole, satisfactory. The mean annual death-rate per 1000 in England and Wales, at all ages, males and females taken separately, has fallen in each of the last three quinquennia, as under:—

	Males.	Females.
30 years, 1841—70	23·3 ...	21·4
5 years, 1871—75	23·3 ...	20·7
5 years, 1876—80	22·2 ...	19·5
5 years, 1881—85	20·4 ...	18·2

Here there is manifested a striking reduction in the general death-rate, both for males and females. But it is desirable to examine this improvement more in detail, and to differentiate for age as well as sex. When this is done, the change in the death-rate stands out very distinctly.

Mean Annual Death-rates in England and Wales for Periods of Years and Groups of Ages; Males and Females separately.

Ages.	Males.				Females.			
	1841—70	1871—75	1876—80	1881—85	1841—70	1871—75	1876—80	1881—85
0— 5	72·5	70·0	67·2	59·6	62·7	60·0	57·0	50·5
5—10	8·6	7·2	6·4	5·8	8·4	6·6	6·0	5·6
10—15	4·8	4·0	3·5	3·2	5·0	4·0	3·6	3·3
15—20	6·7	5·7	5·0	4·6	7·3	6·0	5·1	4·7
20—25	8·9	8·1	6 8	6·0	8·6	7·5	6·3	5·9
25—35	9·8	10·1	8·7	8·2	10·1	9·2	7·9	7·9
35—45	13·0	14·3	13·5	12·7	12·4	12·0	11·2	10·9
45—55	18·5	20·1	19·0	19·4	15·7	15·8	14·9	15·2
55—65	32·0	34·7	34·6	33·6	27·8	28·8	28·9	27·8
65—75	66·7	69·4	67·6	68·8	59·7	61·0	60·2	59·5
75—85	147·4	148·0	146·7	144·6	135·1	134·3	132·3	129·4
85 and upwards	311·6	315·0	304·1	296·4	288·8	285·9	274·0	267·8

From this table it is seen at a glance that the improvement in the death-rate has been very considerable for all ages up to 25; less considerable from 25 to 45 in the case of males, and 25 to 55 in the case of females; and that for subsequent ages the change is, on the whole, somewhat adverse. The proportion of urban population to rural has increased till at the present moment it may be stated as 2 : 1, but despite this fact there has been a striking and continuous fall in the mortality. Of course, it may be argued that the spread of education, and the diffusion of a knowledge of elementary physiological facts, have had something to do with bringing about this result, and the argument is admissible; but they cannot account either for the suddenness with which the fall set in or the persistency with which it has continued. To sanitary works and operations is, probably in a large measure, to be attributed the improvement in the death-rate as shown above, an improvement that gives 1,800,047 additional years of life to the 858,878 children annually born in England, extending the average lifetime of the 437,492 males by nearly a year and a half, and of the 421,386 females by not less than two years and three-quarters. Apparently, we are taking care of the women and children, especially the latter, and if anything could now be done to alleviate the wear and tear of adult life, arising from the increasing severity of competition, especially among men, and to check the evil effects of crowding together in great towns, these remarkable figures might become more remarkable, and human life healthier, happier, and still better worth living.

In conclusion, we may say that the book is clearly and pleasantly written, that the arrangement of the work is excellent, and that, although it cannot contain much that is new, it is interesting from the first page to the last.

BIRD-LIFE OF THE BORDERS.

Bird-Life of the Borders: Records of Wild Sport and Natural History on Moorland and Sea. By Abel Chapman. (London: Gurney and Jackson, 1889.)

THIS is an admirable book of its kind. On the one hand, its "records of wild sport" will be full of interest to devotees of the gun and rod; while, on the other hand, the trustworthiness of its "natural history" is guaranteed by a statement in the preface that the proofs have been revised by Mr. Howard Saunders. But it is not enough to say that the natural history is trustworthy: it is also full of original observations, interesting alike to the bird-lover and the scientific ornithologist. In particular, we may instance a very suggestive chapter on migration, which shows among other things the importance in this connection of distinguishing between a species and its constituent individuals. Certain birds occur in certain regions all the year round, and therefore in those regions might be regarded as non-migratory; but, as a matter of fact, such regions constitute "overlapping zones" doubly crossed by the birds in question during their migrations north and south, so that although the species occupies such a region all the year round, it does so only in virtue of a continual changing of its representative individuals; "those individuals which occupied this area in summer will be wintering 1000 miles south, while their vacated places are occupied by others which had passed the summer 1000 miles north."

Again, there are some curious observations on what the author calls "pseudo-erotism," by which he means a display of amatory instincts which occurs on the part of black-game, plovers, gulls, &c., in October, or even later.

"On wet, foggy mornings in particular, one hears the old blackcocks 'crooning,' 'bubbling,' and 'sneezing,' as excitedly as on a fine day in spring. With a glass, I have watched one surrounded by his harem, strutting round some bare little knowe in the fullest 'play.' . . . Whether this is merely a chronological miscalculation, or arises from some specific cause, the origin of which may be lost in the mists of a remote past, the instinct certainly exists," &c.

There is another point to which we would like to draw attention. It is, of course, well known that telegraph-wires are very destructive of bird life upon open moors; but it is generally supposed that, after the wires have been set up for a year or two, the birds learn by experience to avoid them, and so do not come to grief in nearly such large numbers as they do when the wires are first erected. Now, whether or not this supposition is well founded, it appears certain, from Mr. Chapman's systematic observations upon the mortality thus occasioned, that it occurs perennially to an astonishing degree. The observations were conducted along a line of telegraph wires (nineteen in number), and are as follows:—

"I have heard it estimated by farmers and shepherds (and believe they are not far wrong) that more grouse meet their deaths annually from these mischievous wires than are killed by all the shooters on the moor around. . . . This destruction is going on at all seasons of the year. It is no exaggeration to say that the roadside is, at certain seasons, strewn with remains. Besides grouse, I have picked up black-game, partridge, curlew, golden plover, snipe, peewits, and other birds. Every morning, at break of day, come out the marauding bands of rooks from the lowland woods, reconnoitering along the roadside, and feasting on the dead and dying."

As evidence of the cruelty inflicted by the wires, quotations are made from the author's note-book, of which the following is an example:—

"October 6.—Found to-day four grouse which had been severely damaged by flying against the telegraph wires on Elsdon Hill. Two were already dead, and pulled to bits by the crows. The third had evidently received his wound late the night before, and the blow had completely carried away his crop, which at that time would be full of heather. The poor bird had been hungry this morning, and, regardless or oblivious of having no crop, had been feeding—his throat, down to the huge gash, being crammed with heather-shoots. I never saw anything more pitiable in my life. This bird could still fly, but very weakly, and could not possibly long have survived. The fourth grouse had been injured some time before. He also had received a horrible gash across the breast, but it appeared to be slowly healing."

Now, as Mr. Chapman says "it would be easy to adduce hundreds of similar instances" from his own neighbourhood alone, every sensible man must agree with him when he adds—

"Surely, in these days of ultra-humanitarianism, of R.S.P.C.A. Associations, and of 'Wild Bird Protection Acts'—when a maudlin sentimentality comforts itself by fining a poor man for shooting a wild goose in March, or for overworking his horse on which perhaps depends his daily bread—surely, in these days, the wanton cruelty and useless waste above described (carried on for a national profit) should not be permitted."

Of course the answer to this is, that telegraph wires are nowadays an absolute necessity; but, on the other hand, there is a simple solution of the difficulty, which we will mention in the hope that it may be taken up by the "R.S.P.C.A.," or some private M.P. in search of material out of which to construct a Bill. Let an Act be passed, enjoining that all telegraph-wires extending over moorlands, or other open spaces frequented by birds, shall be run underground.

"Bird-Life of the Borders" is profusely illustrated, and in all respects well deserves the patronage both of sportsmen and field-naturalists.

OUR BOOK SHELF.

Curiosa Mathematica. Part I. A New Theory of Parallels. By Charles L. Dodgson, M.A. Second Edition. (London: Macmillan and Co., 1889.)

WE noticed the first edition of this *brochure* in NATURE (vol. xxxix. p. 124) at some length; and now merely wish to touch upon one or two points which our author animadverts upon in his new preface. Mr. Dodgson apparently fails even now, after our letter in NATURE (*l.c.*, p. 175), to realize our difficulty with the construction in Prop. vi. He says:—"Bisect the angle: that gives halves. Bisect the halves: that gives quarters. Bisect again: that gives eighths. Bisect once more: that gives sixteenths. *Voilà tout!*" Shade of Euclid! who knows not such things? We admitted the same (*l.c.*, p. 175), but stated that our difficulty in the construction was the condition imposed in the enunciation: viz., "the chord of each such sector not less than the radius of the circle." Take Mr. Dodgson's illustration of a sixteenth, this would necessitate that the original angle should be at least 960°. We do not object to that or to any other size. But this, or what is tantamount thereto, we have already brought forward, and have further noted that no one of the chords in Mr. Dodgson's figures is even equal to the radius. But this is not a point touching the author's argument; and we notice it only because he has pilloried us therefor in his new preface, which *some* people will read, contrary to his recorded experience. We thought the remarks we wrote (p. 175) touching viii. and xi. would have amply satisfied him, but he returns to the subject. We need only say that the present enunciations of these propositions, had they been given in the first edition, would have saved us from any misapprehension of the author's argument. This edition is little more than a slightly corrected (there was very little need of correction) and so improved edition. The proof of Prop. i. is new: on p. 9, line 4, an = might advantageously, we think, precede AB. The new forms of viii. and xi. are: "It is not true that the angles of every triangle are together greater than two right angles," and "It is not true that the angles of every triangle are together less than two right angles." On p. 23 there is an uncorrected false reference in line 5 up: for iii. read iv. The proof of xii. has been recast, and in the appendix ii. (pp. 43, 44) about a page of matter, with Euclid's definitions of ratio, has been interpolated. On p. 56 the name R. Simpson occurs twice: it should be R. Simson or T. Simpson. It would be possible now, we should suppose, after a year's interval, to speak in somewhat clearer language ("I understand") of Mr. (now Prof.) Cook Wilson's investigations. After a hasty re-examination of Mr. Dodgson's argument, we can only reiterate our admiration for this first part of the "Curiosa Mathematica." We hope other parts are on the way. R. T.

Longmans' New Atlas. Edited by George Chisholm, M.A., B.Sc., Fellow of the Royal Geographical and Statistical Societies. (London: Longmans, Green, and Co., 1889.)

THIS atlas, although primarily designed for use in schools, aims at being a school and a reference atlas in one, and the attempt to effect a compromise between the two is certainly laudable. It contains 40 quarto and 16 octavo maps, illustrating the physical conditions of the earth, and dealing with climate, vegetation, products, distribution of population, ethnography, and religion. The maps are finished in a good style, and reference to them is considerably facilitated by the system of ledger indexing that has been adopted. In only a few cases has the rainfall been given. It would have been well if a map had been constructed to show the mean annual rainfall over the entire globe.

The magnetic variation map is complete as far as it goes, but since it does not reach below lat. 60° S., the two foci in the southern hemisphere are not shown, and to a beginner it would appear as if such foci existed only in the northern hemisphere.

The physical features of different parts of the earth are generally well illustrated; but in an attempt to eliminate names that have been considered superfluous, it is doubtful whether in some cases the line of demarcation has not been overstepped and the maps left comparatively bare. The two ethnological plates, and the full explanatory note contributed by Mr. A. H. Keane, are worthy of commendation. Some of the subjects of the plates containing typical scenes from different parts of the world seem rather out of place in an atlas like this. We refer to such small cuts as "Children enjoying a Ride on a Dog Sledge" and "Children tobogganning in Canada." Again, another cut which is supposed to illustrate "An Aurora Borealis" is but a mournful representation of one of the grandest of natural phenomena, and might be omitted altogether for the idea it conveys of the character of an aurora.

Most of these plates, however, exhibit the physiographic aspect of different parts of the globe in a very clear light. Indeed, such an atlas as the one before us should play an important part in public school education, and deserves a high place among the political and physical atlases now in use.

Travels in the Atlas and Southern Morocco. By Joseph Thomson, F.R.G.S. (London: George Philip and Son, 1889.)

WHEN Mr. Thomson began his exploration of Morocco, his intention was to write a complete account of that interesting country. His purpose was, however, thwarted by the fact that he was recalled to England much earlier than he had anticipated; so that he has been able to write only a narrative of his personal experiences during his travels. In order to preserve what he calls "the popular and handy character of the volume," he has omitted many things of general and scientific interest which will see the light through more appropriate channels. The book ought to be cordially welcomed by a large class of readers, for it presents many vivid sketches of places which have hitherto been very inadequately known, and the people of Morocco are not less graphically depicted than the physical features of the country itself. Mr. Thomson, we need scarcely say, is a most careful and exact observer, and he has a vigorous, straightforward style, which makes it pleasant for his readers to attend him from point to point of his story. The interest of the volume is greatly increased by a number of admirable illustrations from photographs.

Eclectic Physical Geography. By Russell Hinman. (London: Sampson Low and Co., 1889.)

WE have much pleasure in drawing attention to an English edition of this admirable text-book, which has already been reviewed in our columns. We can confidently recommend it both to teachers and students. The numerous maps with which the book is illustrated will make it especially useful to teachers.

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.*]

"Mithradatism."

I AM anxious to introduce the above word for the purpose of indicating the phenomenon of immunity to poison (whether of bacterial or other origin) induced by administering to an organism gradually increased doses of poison. Mithradates Eupator, the sixth and greatest of that name, King of Pontus, is stated in classical tradition to have so far impregnated his system with poisons on which he experimented, that finally, when he wished to kill himself by some drug, he was unable to do so, having inadvertently rendered himself "immune" or refractory to all known agents of the kind.

I suggested this term in a lecture at the Royal Institution last week; and previously, in conversation with Dr. Roux, in Paris, proposed its use. The utility of the related terms "mithradatize" and "mithradatic" is obvious. The mithradatic theory of inoculations is opposed to the theory of "exhaustion of the soil" and to that of "inhibition by the introduction of chemical substances *directly* inimical to the growth of disease germs."

The Persian god Mithras is not inappropriately associated with the conquest of poisons, since the scorpion was represented as lying at his feet.

E. RAY LANKESTER.

45 Grove End Road, N.W., June 3.

Report of the Royal Commission on the University of London.

WILL you allow me to submit to your readers a somewhat different view of the Report of the Royal Commission from that of the able article which appears in to-day's NATURE?

The writer puts the case clearly and forcibly from the position of University College; and thence, looking down upon the existing University, he recommends it to "afford, by means of a general examination, a test of attainment for students in institutions of as yet imperfect efficiency, and for private students." Those who are justly proud of the work that has been done by the present University (which the Commission fully and unanimously acknowledge) are well aware of its imperfections. More or less "imperfect efficiency" might be asserted of most human institutions. But the University has already elaborated a scheme of reform which in its essentials has been accepted by the Commission; and we may hope that it would grant even more liberal terms in order to secure the great public object of unity. It is beside the mark to propose, not the reform of the University—that both Senate and Convocation desire—not even its destruction, for that would leave the chance of making a better one in its stead; but its perpetuation in a starved, degraded, and hopeless state.

Surely it would be wiser for University and King's Colleges to accept the position offered them of taking the leading part in the reconstituted University, and sharing in its prosperity. For what would they surrender? The faint hope of obtaining a reversal of the Report after an uncertain period of suspense—always trying for a public institution—and then the task of making a new and rival University in London, of providing degrees not inferior in credit and yet not superior in difficulty to those of the older University, of conciliating the antagonistic principles on which the two Colleges were founded and are still supported, and of either persuading richer, larger, and older medical schools to join them, or running great risk of being forsaken by their own medical faculties.

Both Colleges have, under discouragement and undeserved neglect, performed excellent work, and University College in particular has done wonders in the last fifteen or twenty years. They have always had a grievance against the University of London, and were justified in getting tired of waiting on a tardigrade Senate and an amorphous Convocation. They saw a chance of obtaining a new joint charter, and pushed their claims at all hazards, including the loss of some of their most distinguished members. They have not succeeded, and on the whole they will probably be thankful that they have not, for their success would have meant the barter of a splendid birthright for a doubtful immediate triumph.

The writer of the article does not consider the question of the great medical schools of London, except to say that "the rejection of a separate University for Medicine is good in itself"; but in fact the grievance of these bodies is far greater and more pressing than that of University College.

In the real University of London that we all hope to see——teaching, examining, learning, and growing—the three or four best of these schools will form constituents in many respects more academical, more collegiate, and more powerful than the non-medical Faculties of University and King's Colleges. They have traditions, they have endowments, and they have a scientific as well as a purely medical discipline. Their students are for the most part older than those of the Arts Faculties, they have more of a common life, and they are wholly engaged in the studies of the place; whereas a large number of the nominal students in the two Colleges are buyers of scraps of knowledge, rather than University students as the phrase is understood at Oxford, at Edinburgh, or at Leipzig.

The chief difficulty which the minority of the Commissioners have evidently felt is that, by the constitution of the existing University, candidates are admitted to most of its degrees who have passed the several examinations, whether they have been educated in Colleges or no, and whether in London or elsewhere.

But it must be remembered (1) that this was not the original constitution of the University, but a later modification; (2) that the change has never been carried out in the Faculty of Medicine, which is confessedly the most successful of the four, and that practically it has been confined to the Faculty of Arts, which is confessedly the weakest; (3) that there is no insuperable difficulty in the same University granting degrees to collegiate students and to non-collegiate, to local students and to others; for Oxford and Cambridge give the same degrees to men from College and to those who are "unattached," and the University of Dublin has for many years admitted graduates from outside as well as students of Trinity College; (4) that when a teaching University for London has been organized, the number of collegiate students will steadily increase, while that of outsiders will diminish; for local centres will gradually develop and claim independent existence, as they have already at Manchester, at Calcutta, and at Bombay.

Surely, when the first feeling of disappointment has passed away, the Professors of University and of King's Colleges will see that they have still a splendid position waiting for them to occupy. Together with the medical schools, they will enter upon the vantage-ground which fifty years have gained for the present University of London. They will influence, and almost direct, it, if agreed among themselves; and if now and then Doctors and even Teachers find that they cannot have their way in everything, may not the few exceptions be just those in which it is well for the most liberal and enlightened professorial, or clerical, or professional opinion to be moderated by the judgment of laymen?

London needs a University worthy of the greatest city in the world. Three constituents, and three only, are necessary to its formation; and it is not too much to say that no two can make it, but that any one of the three can mar it. To obtain this great public object, the existing University will have to give up many of its prejudices and many of its powers; the medical schools will have to give up some of their independence; University and King's Colleges will give up little but a grievance. In the long run, by united forces, each healthy and vigorous constituent of the renovated University will share in the prosperity and the progress of the whole. The strongest and the best will have the largest share.

June 6. A LONDON TEACHER.

A Lizard Swallowed by a Viper.

As it appears from the "Notes" in the last number of NATURE that the swallowing of a lizard by a viper is not usual, I may mention an instance which came under my own observation. Many years since, I captured a viper on Cannock Chase, in Staffordshire. The animal was rather sluggish, so I got it into a box unhurt, and carried it home. There I shook it out on to the ground. There came out first the slimy body of a *Lacerta vivipara*, followed by a thinner and livelier viper than that which had entered the prison. This result was not surprising, for the victim was about half as long as the swallower, which may explain the ejection of the former when the latter exchanged the fresh air of the Chase for a stuffy box. The lizard, however, in this case was dead, and digestion had begun. T. G. BONNEY.

Remarkable Meteors.

THE spring of 1889 has afforded a very unusual number of fireballs, though it is somewhat rare to find the vernal season prolific in these phenomena. In the autumn, it is true, we frequently hear of conspicuous meteors, but the earlier months of the year are by no means rich in such apparitions.

On March 11, 6h. 36m., a fine meteor of the colour and brilliancy of Venus was seen at London.

March 13, 10h. 25m. Large, bright meteor, without sparks or trail, observed at Dublin.

March 22, 24, 27, and 31. Fireballs appeared at Wexford, Dublin, &c.

April 15, 12h. 24m. Very brilliant fireball observed at Bristol, Bath, Dublin, Lincoln, London, Ramsbury, Worthing, and other places. Though the full moon was shining, the meteor burst out with startling effect, and lit up the sky and landscape for several seconds with a degree nearly equal to daylight.

April 27, 8h. 51m. Fireball equal to Venus seen at Bristol and Trowbridge. It fell vertically and moved slowly from a radiant probably at R.A. 119°, Decl. 28° N., a few degrees east of Castor and Pollux.

May 22, 10h. 8m. A very slow-moving meteor, as bright as Jupiter, and having a great length of path, observed at Bristol, Reading, Clifton, &c.

May 29, 10h. 45m. Fireball, fully 12′ in diameter, and shaped like a club, noticed at Leeds. It travelled with extreme slowness, occupying 9 seconds in traversing the 26° from $141° + 20°$ to $113° + 23\frac{1}{2}°$. Its probable radiant was either at $176° + 9°$ or $210° - 5°$.

Of these various bodies, the most remarkable were those of April 15 and May 22. The former was undoubtedly one of the most brilliant fireballs seen in recent years. The descriptions of its apparent path are not, however, sufficiently precise and accordant to enable its height to be ascertained. It appears to have emanated from a radiant point near Arcturus, and to have been very low in the atmosphere at the time of its final outburst and disappearance.

With regard to the meteor of May 22, it displayed some rather exceptional characteristics, though in point of brilliancy it was certainly inferior to several of the fireballs which have been lately recorded. As observed by the writer at Bristol, it passed about 6° below Vega, and was lost sight of behind buildings, which intercepted the view, when close to η Ophiuchi. Its path of 62° was performed in 16 *seconds*, so that the motion was extremely slow. As the nucleus sailed slowly along, it distributed a train of yellowish sparks in its wake. At Reading, the meteor was seen by Mr. G. T. Davis while observing coloured stars. He noticed its course with particular care as from about 1° west of Corona to between β and δ Scorpii, and gives the points of the observed beginning and ending as $226° + 31°$ and $239° - 24°$, length of track 56°. He notes, however, that this line of flight should probably be extended to include the whole visible arc of the meteor's course. The duration was estimated as 15 *seconds*. A yellow train of 15° in length followed the head of the meteor as it slowly trailed across the sky, and Mr. Davis describes the whole effect as a splendid one. At Clifton an observer watched the object as it passed from the northern [??] sky to the star Vega, and from thence into the north-east confines of Scorpio. He remarks that the most curious point in connection with its career was its long duration, which must have been 18 *or* 20 *seconds*.

Comparing the pair of observations at Bristol and Reading, it is found that the radiant point of this conspicuous meteor was at $63° + 35°$, in azimuth $153\frac{1}{4}°$ (reckoned west from south), and altitude 1°. It was therefore pursuing a course very nearly parallel with that part of the earth's surface above which it appeared. When first seen at Bristol it was passing over a point 6 miles east of Oxford at a height of 50 miles. The Reading observer caught sight of it when 6 miles east by south of Farnham, the height being the same. When the object was obscured by houses at Bristol, its height had increased to about 55 miles. At Reading it was last seen when above a point 10 miles west of Orleans, in France at a height of 58 miles. The rapidly increasing distance of the meteor prior to its disappearance was of course due to the earth's curvature.

The real length of path observed at Bristol was 196 miles, described in 16 seconds, so that the velocity was $12\frac{1}{4}$ miles per second. At Reading the length was 249 miles in 15 seconds—velocity $16\frac{1}{2}$ miles per second. Parabolic velocity would be about 20 miles per second, so that it is probable the meteor was revolving in an ellipse of very slight eccentricity—in fact, the orbit appears to have been nearly circular in form.

The radiant point of this meteor is situated some 7° south-east of ϵ Persei. The position is a very unusual one for a meteor shower occurring at this period of the year. When the effects of zenithal attraction are allowed for, the radiant is found to be several degrees below the position as above assigned from a simple projection of the two paths, and within about

12° of the sun's place. The very slow motion of the meteor, its considerable length of path, and the exceptional point from which it diverged, combine to render it an object of especial interest, and further observations of its apparent path would be valuable. It probably became visible at an earlier part of its path than when first seen at Bristol in Lyra, and it is desirable to ascertain, if possible, a more precise result for its point of appearance. The entire length of its course might then be derived, when it would possibly be found that the distance assigned from present data is much shorter than that really traversed by the meteor. The Bristol and Reading observations indicate the whole length as nearly 300 miles, and this, though undoubtedly under the true value, is yet far greater than the customary tracks over which the flights of these bodies extend.

Bristol, May 31. W. F. DENNING.

Palæolithic Implements from the Hills near Dunstable.

DURING the past twelve months I have found a small number of Palæolithic implements at great elevations in North Hertfordshire and South Bedfordshire, unconnected with existing river valleys. Four of the implements—1386, 1387, 1393, and 1398 in my collection—are from Caddington: height above Ordnance datum, 595 feet 9 inches. The dry valley close by, to the west, is 470 feet, and the ground gradually falls southwards to 409 feet at the source of the Ver, near Markyate Street, at a distance of $1\frac{3}{4}$ mile. The sections at Caddington exhibit red "clay with flints," brick earth (or clay), and tenacious brown clay or loam, surmounted by blackish earth, containing broken white-coated flints, a few ochreous flints, and numerous blackish Tertiary pebbles. The whole deposit rests on chalk, and varies in depth from 2 feet to 50 feet. Aware of the importance of finding the worked flints in the undisturbed material, I have, after long searching, found a single implement and one or two flakes *in situ* at the stony bottom of the upper deposit of tenacious brown clay at a depth of 3 and 4 feet from the surface. A single small Palæolithic implement I have found on the surface at Kensworth: height above Ordnance datum, 759 feet 8 inches. The bottom of the valley, $1\frac{1}{4}$ mile to the west, at the source of the Ouzel, is 414 feet. Half an ovate Palæolithic implement, obviously derived from the hill-tops, I have found in a field at the bottom of a chalky valley near Houghton Regis. The Caddington implements are pointed (or tongue-shaped), slightly abraded, small in size, and cinnamon-brown in colour. The interest attached to these finds rests not only on the great heights mentioned and the positions away from existing river valleys, but in the nature, age, and mode of deposit of the upper tenacious brown clay in which the implements are embedded. The implements themselves agree in make and appearance with the well-known brown or ochreous implements often found in non-ochreous sand, &c., in existing river valleys. I have at present seen no traces of fossil bones or fresh-water shells in the deposits mentioned. WORTHINGTON G. SMITH.

Dunstable.

Japanese Clocks.

WITH reference to your notice of the Japanese clocks purchased for this Museum, and described by Mr. A. Rambaut, it may prove of interest to point out in somewhat fuller detail the conclusions at which he has arrived as to the cause of the peculiarities in their construction It was on account of these, to me, unintelligible peculiarities, that I invited Mr. Rambaut to undertake their explanation, and this, I venture to think, he has very thoroughly accomplished as follows. The three clocks agree in having a dial on which the time is indicated by a pointer attached to, and descending with, the weights. In other respects they differ, though all are made more or less on the same principle. The largest of the three appears the most important, and the greater part of the paper is occupied in explaining its construction. The dial of this is divided by vertical lines into six equal spaces, which are crossed by a series of thirteen graceful curves. An examination of these curves leads to the conclusion that they were intended to divide the day and night, at all seasons of the year, into six equal portions each. This system was common enough in ancient times, but the peculiarity of these clocks is that they show the day to have been reckoned, not from sunrise till sunset, but from the first noticeable streak of morning twilight until the sun had reached a corresponding distance below the western horizon. This distance is equal to 13°, and the form of the curves leads to the conclusion that the clock was constructed in a latitude of about 34° 7′, very little less than that of Miako, formerly one of the principal cities in Japan. An examination of the two other clocks, although they differ very much in detail, supports the conclusions derived from a study of the first. V. BALL.

Science and Art Museum, Dublin, June 1.

Luminous Night-Clouds.

FOR the first time this year these clouds appeared in this locality last night, between 10 p.m. and midnight. I inclose sketches, as with my reports in former years, made at half-hour intervals, exhibiting development and movement; which latter has been in this case from west to east, a direction the reverse of light local wind. A depression of temperature was noticed, as on former occasions. Minimum (on grass) fell to 40° F.

It may be remembered by some of your readers that when first pointing attention to this annual phenomenon some years ago, and affirming the self-luminous character of these cloudlets, at apparently high altitudes, the name "nubeculæ boreales" was suggested to distinguish them from simple auroral effects. Herr Jesse, of Berlin, has recently (NATURE, vol. xxxix. p. 537) noted their occurrence toward the South Pole also, and pointed to their probable cosmical importance. Detailed observations of any of your correspondents, made during the present reappearance of this phenomenon, would be accepted by the writer thankfully, toward a fuller discussion of the subject. If, as would appear, it is chiefly of a Polar character, the name proposed should be modified to include the South Pole, and these clouds so designated "nubeculæ polares" (or "noctilucæ").

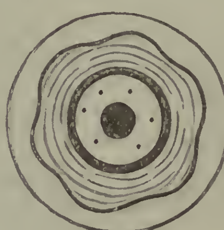
D. J. ROWAN.

Dundrum, Co. Dublin, June 8.

Note on some Hailstones that fell at Liverpool on Sunday, June 2, 1889.

BEING in the Physical Laboratory at about 3.35 p.m., about which time a violent thunderstorm took place, accompanied by hail and rain, I went outside and picked up what seemed to me a fine specimen of hail. I brought it inside, measured its diameter with a pair of calipers, and found it to be 2·9 centimetres.

I then placed it on a slate slab, on which it gradually melted down until it showed a very fine section, a picture of which is given below.



The centre was circular, and consisted of opaque ice, about the size of an ordinary hailstone; this was surrounded by a circle of almost perfectly clear ice, this again by a circle of opaque ice, and this once more was surrounded by almost clear ice, but with fine circular lines in it, and bounded by a beautifully frilled outline of opaque ice, which imitated in shape the spheroidal state of a drop of water. Outside this again was a thick layer of clear ice of crystalline form, the position of whose angles I have not shown, as I did not observe their position with regard to the frill inside sufficiently well.

The diagram is drawn to the right size, omitting the angles on the outer covering of ice, the dark parts represent white opaque ice.

If a hailstone is formed during electric oscillation from cloud to cloud, and if it receives opaque ice from one cloud and clear ice from another, the alternation of layers would be a natural consequence. The violence of the hail scarcely seemed as great as their size justified, and this suggested that electrostatic attraction had upheld them against the force of gravitation down to a moderate height above the ground.

I believe almost all the lightning flashes that occurred were between two clouds, as, although I was looking out for the form of the flashes, I could only see the sky lit up with a brilliant red or pinkish glow. Dr. Howard found some hailstones that were cylindrical in form; those that I found were approximately round but for the sharp edges of crystalline structure. Mr. B. Davies measured one and found it to be 3·5 centimetres in diameter. All the large stones that I found showed the same construction; in every one there was the same frilled appearance of an internal surface: this was also observed by Mr. B. Davies.

EDWARD E ROBINSON.

Physical Laboratory, University College, Liverpool.

THE SUBDIVISION OF THE ELECTRIC LIGHT.

TEN years ago the subdivision of the electric light was the burning question of the day. Again it has been revived, but the present subdivision is a legal and not an electrical problem.

The public interest in electricity roused by the sensational telegrams about Edison's work in 1878–79, and by the wonders seen at the Paris Electrical Exhibition in 1881, as well as at the Exhibition at the Crystal Palace in the following year, made people reflect that the electric lighting of our streets and houses might breed a monster as tyrannical as the water companies; consequently, paternal legislation passed an ill-considered Bill, the "Electric Lighting Act of 1882," to curb electrical repaciousness.

But had our law-givers paid attention to what was taking place in the City, and had they also possessed some acquaintance with the difficulties connected with the problem of electric distribution, they would have seen that it was on the Stock Exchange that the devouring electric Hydra was rampant, and that the general supply of electricity was in 1882 but a weak puny infant, which would require the most tender care to enable it to reach boyhood. Instead, however, of fostering the babe, the framers of the Act of 1882 showed their absolute ignorance of the way in which a new industry grows up, by introducing a clause which specified that at the end of twenty-one years the local authority might take over any installation for electrically lighting a district on paying the simple market value of the land and plant without giving anything for good-will. In view of the improvements in electrical machinery that might be expected to take place in twenty-one years, it might have been anticipated that before the end of this period the dynamos and other apparatus might very properly have been replaced twice over, in each case more efficient apparatus being substituted for less perfect: but the local authorities were still to be empowered to step in, to disregard all that had been done in building up a good business, and purchase the whole as a going concern for the mere market value of the land and plant. Hence the progress of electric lighting in England was strangled at its birth, while vast sums were squandered on the legalized gambling of the Stock Exchange, the public being unmercifully fleeced, and then left without electric lighting or belief in it.

This instance of paternal legislation was but a repetition of the one-sided Act passed to remedy the extortion that sometimes accompanied the operation of bills of sale. In this case the interests of the borrower were alone present in the minds of the framers of the Act, and they quite forgot that by making the recovery of debts on bills of sale very difficult they would introduce a new and even greater hardship, by making the borrowing of money on bills of sale frequently impossible.

This bone of contention, the Electric Lighting Act of 1882, was steadily snarled over and growled at, until last year the two Houses of Parliament saw fit to swallow a new Act, which, by extending the period of compulsory purchase to forty-two years, and by recognizing that the development of an electric light installation might represent something much more valuable than the market value of the land and plant, has at last made the general distribution of the electric current commercially possible.

But in the meantime, over a vast area extending from Regent's Park on the north to the Thames on the south, from the Law Courts on the east to Park Lane on the west, some thousands of electric lamps had been dotted, all fed from one central station in the basement under the restaurant of the Grosvenor Gallery in Bond Street. And to avoid the difficulties that would be introduced by the clauses in the 1882 Electric Lighting Act, if the streets were broken up and the wires put underground, the London Electric Supply Corporation, to whom the Grosvenor Gallery installation belongs, erected their cables, some 50 miles in length, over the tops of the houses. Hence, the legislation that was intended to avoid a vested interest being acquired in street conduits has forced the erection on the house-tops of a network of high-pressure mains which have now to be specially legislated for.

The productive capacity of the Grosvenor Gallery plant having been fully reached, while applications to supply current for thousands of incandescent lamps had to be shelved for want of means of generating the necessary current, the London Electric Supply Association commenced the erection of a vast station on the banks of the Thames at Deptford for the supply of current for some millions of incandescent lamps; and it has been mainly due to the application on the part of the company to obtain powers to run their wires along twenty-seven railways and tramways, and through thirty parishes, that the recent inquiry by the Board of Trade, lasting from April 3 to May 1, has been held to examine into the whole question of the electric lighting of London. The result of this inquiry is contained in a long Report that has just been submitted to the Secretary of the Railway Department of the Board of Trade by Major Marindin, this Report being agreed to by Major Cardew.

Eight companies—viz. the Chelsea Electricity Supply Company, the Electrical Power Storage Company, the House to House Electric Light Supply Company, the Kensington and Knightsbridge Electric Lighting Company, the London Electric Supply Corporation, the Metropolitan Electric Supply Company, the Notting Hill Electric Lighting Company, and the Westminster Electric Supply Corporation—applied for thirteen provisional orders and two licenses. A license is a permission granted for seven years, but it is renewable at the end of this period. The Board of Trade, however, can only grant a license when the consent of the local authority has been previously obtained. A provisional order, on the other hand, requires no consent of the local authority of the district, and is granted for a period of forty-two years. After a provisional order has been approved of by the Board of Trade, it requires to be confirmed by a Bill in Parliament before it can come into force. Neither the license nor the provisional order when granted is exclusive or creates any monopoly.

The first point considered in Major Marindin's Report is the systems of supply proposed to be used by the various companies applying for powers. They may be divided into a supply by direct current, and a supply by alternate current. The direct supply by means of continuous currents is dealt with under three heads:—(*a*) The system adopted by the Chelsea Company—viz. the use of one generating station for a considerable area, supplying current to charge several accumulator stations at different points within the area of supply with a pressure of from 1000 to 2000 volts, each station having a duplicate set of accumulators. The supply mains leading from these accumulator stations are intended to carry the current directly into the houses at a pressure of 100 volts, the supply being entirely from the accumulators. This is the system of transformation that was originally suggested by Sir William Thomson at the meeting of the British Association at York. (*b*) The system adopted by the Kensington and Knightsbridge Company, which is at the present moment supplying partly by accumulators and partly by dynamos—the former doing the whole work during the hours of minimum supply, and the latter being employed in charging the accumulators and supplementing the direct supply from the accumulators during the hours of maximum supply. The accumulators are all stationed at the generating station, and merely serve as a reserve of power. Since they are not employed to effect a transformation from a high to a low pressure, they do not introduce any saving in the size of the distributing mains, as in the case of the Chelsea system. Hence the Kensington system, which the Notting Hill Company proposes also to adopt, would require several generating stations for the lighting of a large area. (*c*) Direct supply at low pressure without the use of accumulators, such as is at present employed by the St. James's and Pall Mall Company. This system is also only suited for distribution over small areas, not exceeding half a mile in radius, since the absence of any system of transformation necessitates the employment of very large conductors. This last system has also the disadvantage of alternate current distribution, as the supply, being directly dependent on the steady working of the machinery, is liable to be seriously affected by even a temporary breakdown, which is, of course, not the case with the direct current systems (*a*) and (*b*).

It is interesting to note that no system of direct current transformation, other than that effected by the use of accumulators, has been proposed by any of the companies or referred to in Major Marindin's Report; probably because all direct current transformers, "motor-dynamos," &c., that have yet been devised, employ moving parts, and are therefore in their present form unsuitable for transformation in private houses. We cannot, however, but think that such direct current transformers might be very economically employed at distributing stations, the energy being received at high pressure from the main generating station, and distributed at low pressure to the houses in the neighbourhood of the distributing stations.

The House to House, the London Electric Supply, and the Metropolitan use high-pressure alternate currents with transformers, except in the case of the Whitehall installation of the last company; and it speaks well for the alternate current system that, while the Metropolitan Company commenced at Whitehall with direct currents and accumulators, which they first thought so superior to the use of alternate currents, they now state in their evidence that in their extensions they propose employing alternate currents and transformers. In the case of the London Electric Company, a *double system of transformation* is to be employed between the current leaving the dynamo and the current in the houses of the consumers. The supply will be obtained from a very large generating station at Deptford, outside the crowded districts of the Metropolis, and carried through trunk mains, at the unprecedentedly high pressure of 10,000 volts, to transforming stations inside, or near, the area of supply, whence the current will be taken by distributing mains, at a pressure of 2500 or 2000 volts, to the consumers' premises, and transformed there to 100 or 50 volts. Or this second transformation may be effected at secondary transforming stations, the currents being conveyed from them to the houses at the pressure of 100 or 50 volts.

In the case of the House to House and Metropolitan Companies only one transformation is proposed to be employed, so that several generating stations must be erected; as even with a pressure of 2000 volts the conductors would have to be inconveniently thick if the electric energy were conveyed very far. The Metropolitan Company have, therefore, selected sites in Sardinia Street, Rathbone Place, South Mews (near Manchester Square), Eccleston Place, and Waterloo Bridge Wharf; from each of which a current at 1000 volts will be sent, to be transformed into 100 or 50 volts inside the consumers' premises.

The Report contains a concise account, written by Major Cardew, of the relative advantages of the direct and of the alternate systems. He refers to the fact that the employment of accumulators by the Chelsea Company at their distributing stations enables small distributing mains to be used; makes the lighting of the district unaffected by even a temporary total breakdown of the machinery, since the accumulators that are at any time supplying current to the houses are quite distinct from those that are being charged; enables a nearly constant pressure to be maintained at the houses, independently of the number of lamps that are turned on; and, lastly, the current being a direct one is applicable for the supply of motive power and for other uses besides the production of light and heat, and can be more easily measured than an alternate current. Major Cardew further adds, as an additional advantage possessed by supplying current from accumulators, that "there is no doubt that a battery current is less destructive to lamps than one supplied from dynamos, whether alternating or continuous." We doubt, however, whether there is sufficient experimental evidence on this subject to justify this conclusion.

As a set-off to these advantages the cost of accumulators is great, as well as that of the skilled attention they require, while their efficiency at maximum output is probably rather low; the automatic switches for switching the accumulators into the charging circuit when discharged and into the discharging circuit when charged, as well as for regulating the discharge from each cell, are, Major Cardew thinks, a weak point, and any failure in their action would probably ruin the accumulators; the insulation of large batteries cannot be maintained at all high; and the numerous joints that have to be maintained good in the presence of acid fumes are a source of weakness.

The special advantages of the high-pressure transformer system Major Cardew considers to be: the smallness of the mains; the absence of difficulty in maintaining constancy of pressure in the mains within 2 per cent. over a large area; the pressure in the houses may be different in different cases according to the needs of the consumer; the system is simple to work; the dynamos are simple, and can be made in easily replaceable parts.

The disadvantages are that the high pressure necessitates great care and expense in insulation; the conveying of this high pressure to at any rate one point on the consumer's premises involves some risk to life; the main cannot be handled nor connection made with it when the pressure is on; the transformers cause the regulation in the houses to be not so good as in the mains; the system cannot at present be efficiently utilized for motive power, or for electric deposition or other chemical uses, such as charging accumulators; "and it is very doubtful whether a practically successful alternating motor is likely to be brought out"; the system depends entirely on running machinery; the general efficiency must be low when the supply is near its minimum, which, so long as it is utilized for lighting alone, obtains during about eighteen hours out of the twenty-four; a serious accident at the generating station might stop the supply. "Alternating machines cannot be so readily connected together to run in parallel circuit as continuous current machines"; the instruments and methods for making measurements are far more restricted in number, and the measurements are more difficult to make, when alternate currents are in question.

The sentences in the preceding paragraph that are placed in inverted commas appear to us to be particularly rash. So far from saying "it is very doubtful whether a practically successful alternating motor is likely to be brought out," we should prefer to say that it is almost certain that, as soon as there is a widespread demand for cheap efficient alternate current motors, such motors will be forthcoming; and, after the experiments shown by Mr.

Mordey at the end of May, at the factory of the Anglo-American Brush Company, on the great facility with which alternate machines can be coupled in parallel, Major Cardew must, we think, wish that he had worded the sentence quoted above somewhat differently.

Major Cardew next criticizes the objections that have been urged against the particular scheme involving two transformations of the pressure, which the London Electric Supply Association are arranging to carry out: that having only one generating station an accident might stop the whole supply of current to hundreds of thousands of incandescent lamps. To avoid, for example, the bursting of a steam-pipe greatly impeding, if not entirely stopping, all work by filling the factory with steam, and by the steam condensing on the dynamos and fittings, and so causing the high-pressure current to flash where it ought not to go, Major Cardew recommends that the Company shall subdivide the station at Deptford so as practically to provide two distinct generating stations, or shall forthwith establish a second generating station in some other locality. With reference to another objection, that the proposed pressure of 10,000 volts is so enormously in excess of anything which has hitherto been worked with, as to cause the scheme to be a gigantic experiment, he very rightly points out that, as there has been successfully used for some time at the Grosvenor Gallery installation over ten times the pressure that was believed to be the limit of safety a few years ago, "and as the so-called experiment of still further raising the limit of pressure would, if successfully carried out, be of immense benefit both to the public and electric light undertakers, I do not consider that, under proper regulations, the London Company should be prevented from carrying out a scheme in which they have shown the greatest confidence, and which the majority of scientific witnesses who have been called approve of in principle." With this recommendation we heartily agree, since all past history has shown that it is better to be guided by experience than by preconceived notions.

The final conclusions arrived at in the Report embrace several pages, but they may be briefly summed up as follows:—"That it must be admitted that the science of electric lighting has now reached the point at which a supply can be made which will be of great benefit to the public, and that the power of obtaining this supply should be within the reach of all persons who may require it," and therefore, although the wishes of local authorities should be consulted, "the mere objection by a local authority to the introduction of a company proposing to supply electric light, upon general grounds, should not be considered sufficient to exclude such company." As the whole Metropolis may be for purposes of lighting and management of roads and streets under the control of one central authority, "the provisional orders granted for the Metropolitan area should, as far as possible, be identical in form, with identical provisions as to supply, compulsory powers, interference with streets, and more than all as to price."

That the scheme adopted in 1883, of dividing a district into two areas (A) and (B)—the former an area that it was compulsory for the company obtaining the provisional order to light; the second an area which the company might light if they thought fit, but which they could not be required to light until after the expiration of two years—be abandoned, as such a distinction of areas is not likely to work well, and is not contained in the Electric Lighting Act, being merely introduced for the purpose of convenience; and that instead the supply shall be compulsory, under requisition, over the whole area on equal terms. That, "taking the (Metropolitan) area as a whole, it does not appear that it would be wise to fix a lower maximum than 8*d*. per unit." One Board of Trade unit is one thousand watts for one hour, so that at three and a half watts per candle, which is a fair average efficiency for an incandescent lamp, if it is to have a decent life, and assuming that a sixteen candle-power gas-burner consumes 5 cubic feet per hour, the maximum price proposed for the electric supply is equivalent to gas at 7*s*. per 1000 cubic feet, or nearly three times the present actual cost of lighting by gas. In the draft provisional orders several companies have asked for the right to make a certain minimum charge irrespective of the amount of electric energy consumed; and in the case of the Metropolitan Company, they ask to be allowed to charge a householder who has electric lamps in his house £5 10*s*. a quarter even if he never turns on a single lamp. Of course such a high minimum charge would be absurd, and even that of 13*s*. 4*d*. per quarter, which the Report appears to consider a reasonable one, appears to us much too high. In fact, we think that the proposal that there should be no minimum price at all if the householder pays for connecting his house with the mains might have been strongly urged in the Report, instead of it being stated that "such a provision would hardly be necessary where the minimum is reduced as in the Metropolitan Orders,"—that is, to 13*s*. 4*d*. a quarter. It is further recommended that there shall be a revision of the prices in the form of a sliding scale based upon the basis of a 10 per cent. dividend, the standard being fixed after the experience gained by the working of the first seven years.

In view of the fact that the laying of the mains of several companies means so much dead capital which the local authority would have to pay for if it elected to purchase at the end of forty-two years, and that no matter what regulations be made as to laying of mains the interference with the street must be to a certain degree proportionate to the number of companies having powers over this street, it is recommended that powers should not be given to more than two companies over the same area, and that one of these companies should be a company using the direct current. The following is very important, since if passed it will entail a vast expense on the London Electric Supply Corporation:—"That wherever a company now supplying a district by means of overhead wires is granted an order for such area, it should be placed under the obligation to remove these overhead wires within a period of two years from the granting of the order; and if such a thing be possible that this company should be prevented from invading a district in which it has not got powers by means of overhead wires."

At this Board of Trade inquiry many arguments *pro* and *con* were advanced as to the large companies being allowed to invade the areas that had begun to be worked by small companies. The large companies raised the "no monopoly" cry, and urged that they ought to be allowed to compete everywhere; whereas the smaller companies alleged that the most certain way to bring about monopoly would be to allow the large companies to enter the areas worked by the small companies, and to use the profits gained by the large companies in non-competing districts to enable them to work for a time at a loss in the competing district, and by underselling the smaller companies to eventually drive them out and have the whole field to themselves. Taking all points into consideration, Majors Marindin and Cardew recommend that there be allotted to—

(1) The London Electric Supply Corporation: the portions of St. Martin-in-the-Fields lying to the south of the Strand and west of St. Martin's Lane; the portion of St. Margaret and St. John, Westminster, lying to the north of Victoria Street, excepting that portion of St. Margaret lying to the west of St. George, Hanover Square; St. James, Westminster; St. George, Hanover Square; Chelsea; the Greenwich District; St. Mary, Rotherhithe; St. Mary, Bermondsey; the district of St. Olave; the district of St. Saviour, Christchurch; and that portion to St. Mary, Lambeth, lying to the north of Westminster Bridge Road.

(2) The Metropolitan Electric Supply Company: St. Giles-in-the-Fields; St. George, Bloomsbury; St. Andrew, Holborn, above Bars; St. George the Martyr; St. Sepulchre, Saffron Hill; Hatton Garden; Ely Rents and Ely Place; the Liberty of Glasshouse Yard; St. Anne, Soho; St. Paul, Covent Garden; St. John the Baptist; Savoy, or precinct of Savoy; St. Mary-le-Srand; St. Clement Danes and the Liberty of the Rolls; together with the extra-parochial places known as the Charter House, Gray's Inn, Lincoln's Inn, Staple Inn, and Furnival's Inn; St. Marylebone; St. Mary, Lambeth; St. Leonard, Streatham, and Clapham; that portion of St. Martin-in-the-Fields which lies to the east of Northumberland Avenue, Charing Cross, and St. Martin's Lane.

(3) The Chelsea Electricity Supply Company: the small portion of the parish of St. Mary Abbotts at the east end of the parish contiguous to Chelsea, which has already been agreed to by the Kensington Vestry; as well as the following, which has up to this time been refused by the Vestry of St. George, Hanover Square, viz. so much of the parish of St. George, Hanover Square, as is between the line formed by the eastern boundary of Chelsea parish on the west, by Knightsbridge, St. George's Place, and Hyde Park Corner, on the north, and by Grosvenor Place, Upper Grosvenor Gardens, Lower Grosvenor Gardens, Buckingham Palace Road, Commercial Road, and Bridge Road, on the east and south-east.

(4) The House to House Electric Light Supply Company: the south-western portion of the parish of St. Mary Abbotts, Kensington, which has been offered to this company by the Vestry, and which it is willing to accept.

(5) The Kensington and Knightsbridge Electric Lighting Company: the portion of the parish of St. Mary Abbotts, Kensington, which this company is at present lighting under licence from the Vestry; so much of the parish of St. Margaret, Westminster, as lies to the west of the parish of St. George, Hanover Square, which is at present worked under licence from the Vestry of St. Margaret and St. John, if the consent of this Vestry, which is at present refused to the issue of a forty-two years' provisional order, can be obtained.

(6) The Notting Hill Electric Lighting Company: the portion of the parish of St. Mary Abbotts, Kensington, which has been allotted to the company by the Vestry.

(7) The Westminster Electric Supply Corporation: the parish of St. George, Hanover Square; and the portions of St. Margaret and St. John, Westminster, lying to the south of Victoria street.

(8) As regards the Electrical Power Storage Company: that as the articles of association of this company do not give it any power to manufacture and supply electricity for house-to-house lighting no provisional orders be given.

Lastly, that the licenses applied for by the Chelsea and House-to-House Companies for areas in the portions of the parish of Kensington already allotted to these companies by the Vestry be granted.

As regards the City itself, the Commissioners of Sewers, acting for the Corporation, are asking for tenders; but Major Marindin says that he sees "no reason why the principle that all such lighting should be done under statutory powers and obligations should be departed from in their case;" and he recommends that the Board of Trade should "urge the Commissioners of Sewers to consider whether the orders as remodelled do not sufficiently provide for all their requirements, and to consent to a division of the area of the City between the two competing companies, viz. the London and Metropolitan Companies, the latter company being allotted the portion nearest the Strand District, and the former the Central and Eastern portions of the City, so that access may be given to the parish of Clerkenwell, the Vestry of which wishes for an order to be granted to this company."

Major Marindin's Report was forwarded on May 18, by the Board of Trade, to the London County Council, for an expression of their opinion on the subject; and the Clerk to the London County Council has within the last few days sent a reply to the Assistant Secretary of the Railway Department of the Board of Trade. In this reply, while expressing the general approval of the Council to the recommendations contained in Major Marindin's Report, he communicates the following important suggestions, among several others, which the London County Council desires to make:—

"That in the case of subways being in future made in streets where wires are already laid, the companies should be under an obligation to remove the wires into such subways, and to pay a rent for the use of them, a reasonable time (say three years) free of rent being allowed as a set-off to the cost of such removal."

Such a regulation it appears to us would be very onerous in the case of companies like the Kensington and Knightsbridge Company, who have gone to a considerable expense in making small special conduits for their own wires.

"That in view of future possible reduction in the cost of production which may be made as the result of experience and invention there should be a provision that the maximum price of 8*d*. per Board of Trade unit, proposed to be adopted, shall be subject to revision at the end of seven years; and that in order to insure healthy competition between the companies during that period no amalgamation or working agreement between companies shall be permitted without the consent of the Council. That clauses should be inserted providing for the application at the end of seven years of a sliding scale of price and dividend, on the basis of a dividend of 8 per cent." (not 10 per cent. as recommended by Major Marindin to the Board of Trade), "leaving the initial price and arrangement of the scale to be determined at the expiration of the term of seven years.

"That the minimum charge for supply should be fixed as low as possible, and that should such minimum be fixed at £1 per quarter or over it should be reckoned by the year and not by the quarter, because of the irregular requirements of the consumer at different seasons of the year."

We presume this is to prevent a company charging a householder by meter in the winter quarters, and levying the minimum rate in the summer quarter.

"The Council considers that it would be to the advantage alike of the public and the companies that there should be one uniform system of regulation and control throughout the entire area of London. The Council is of opinion that, as the representative governing body of the whole of London, it should be appointed the controlling authority. The Council would further suggest that, if it be made the controlling authority, it should be empowered to discharge the following duties, viz.:—

"Inspection of lines and works.

"Testing current.

"Testing and certifying meters."

We do not know whether the London County Council is aware that a Committee of the Institution of Electrical Engineers, and a Committee of the Electrical Section of the London Chamber of Commerce, have for some time past been engaged in advising Major Cardew regarding the details of an electrical standardizing laboratory to be fitted up for the use of the Board of Trade; and we think that, while municipal regulations may very properly be left to the County Council, the standardizing and certifying of meters would more appropriately form part of the work of that body which is already in charge of the national standards of weights and measures, viz. the Board of Trade.

The letter of the Clerk of the Council goes on to say:—

"The Council, in view of the fact that some companies have been, and are now, supplying electricity by overhead wires without statutory powers, and being convinced of the undesirability of allowing this to be continued, would venture to suggest that, in any further legislation on electric lighting, the supply of electricity in any district, before obtaining statutory powers for such district, should be prohibited under penalty."

To this we see no objection, now that the Electric Lighting Act is so modified that it is possible for an electric lighting company to reap commercial success by working under it.

THE LIFE-HISTORY OF A MARINE FOOD-FISH.[1]

II.

THE larval salmon enters the world of a size—though small—that is readily recognizable, viz. about three-fourths of an inch in length, but the marine forms under consideration, from their minute size and glassy translucency, are almost invisible to the naked eye—just a gleam of light broken by the passage of a different medium, or a tinge of pigment, arresting attention. Only in the cat-fish (which is not much—though it ought to be more—of a food-fish) with its large egg, have we a size nearly reaching that of the salmon at birth.

We had left the larval fish tossed about by the currents and unable to struggle against them, now floating with its yolk-sac uppermost, or hanging in the water with its head downward, and again making spasmodic darts hither and thither. Soon, however, it gathers strength, and at the end of a week or ten days it glides actively through the water, and avoids both obstacles and enemies, the young cod nimbly escaping the forceps, poising itself in the water with its large pectoral fins (Fig. 11), and

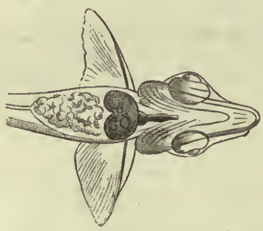


FIG. 11.—Ventral view of the anterior region of larval cod (magnified).

evincing both intelligence and dexterity. Moreover, this activity greatly promotes respiration in those like the gunard with a motionless mandible, the water being thus sent through the mouth and over the branchial region. Its mouth has now opened and the yolk-sac has been absorbed, while it feeds on the most minute of the little Copepods, especially those almost microscopic in size, that swarm in the surrounding water. The provision whereby such tiny fishes find in the ocean food suited to their capacities is one of the most striking features in Nature, but it has only recently been carefully investigated. It is a notion no longer tenable that during the winter and spring the sea, to a large extent, is devoid of the wealth of pelagic life so characteristic of the summer months—just as it is of the genial waters of the tropics. For several years, however, it has been found that a vast abundance of minute life of all kinds is present throughout the entire year—and from the surface to the bottom. Moreover, during the warmer months a constant succession of young forms rises from the eggs both of the sedentary and creeping animals on the bottom to the surface, where they sport in the summer sun, undergo certain changes, and again descend as they assume the form of the adult. The pelagic young food-fishes—swimming freely in the ocean—thus have a double chance at them; first in their very early stage as they rise, and again in their larger and later condition as they descend. The enormous numbers, countless variety, and ever-changing nature of the small animals either directly or indirectly constituting the food of these little fishes form an important feature in the economy of the sea. Such animal forms comprise those long known in the British seas, besides others more familiar to Arctic voyagers, or to the sunny waters of the Mediterranean, for, with modern apparatus and persistent efforts (thanks to the enlightened views of the Government acting through the Fishery Board), our knowledge is always extending.

It is a remarkable fact that it is primarily to plants in inshore waters that the abundance and variety of animals are in many respects due, especially if estuaries also debouch in the neighbourhood. Thus nowhere are the swarms of Sagittæ, Appendicularians, Crustaceans, and other forms of fish-food more conspicuous than in the midst of a sea teeming with Diatoms, Rhizosoleniæ, and other Algoid structures.[1] These nourish many of the lower forms upon which the Crustaceans and other higher types feed, the latter again falling a prey to the fishes. Moreover, while the larger forms of the Copepods and other Crustaceans, for example, afford suitable nourishment for the more advanced post-larval fishes, the multitudes of larval Crustaceans (*Nauplii*) are adapted to the needs of the smallest larval food-fishes. Now this plant-life is specially abundant in April and May, just when the larval and very young post-larval fishes appear more abundantly in the inshore waters, so that the cycle is nearly complete, viz. from the inorganic medium through microscopic plant and larval Crustacean to the post-larval fish. I have mentioned the neighbourhood of an estuary as a prolific source of food for young fishes, and I need only explain further by instancing the case of mussel-beds, which for months pour countless myriads of larval mussels into the adjoining sea, far beyond the needs of the area as regards mussel-culture, but which form a favourite food of the little fishes at all stages, but especially from an inch and a half to three inches in length. These fishes feed on the young mussels as they settle down on the seaweeds, rocks, and zoophytes in August, after a free-swimming larval existence. Like some of the forms indicated above, mussels live to a considerable extent on microscopic plants and various minute organisms contained in the mud of the estuaries and other sites, so that a rich and favourite food, universally liked by fishes, is the product of these uninviting flats. Moreover, in passing, it may be remarked that, while everywhere preyed on by the food-fishes, it occasionally happens that in turn the mussel proves a source of inconvenience to them, for, settling on the gill-arches of haddocks, the mussels flourish on a site so suitable for aëration and food that they by and by press out the gill-cover and impede respiration, just as the shore-crab (which is also fond of mussels) has its eye-stalks wrenched out by the slow but sure growth of the young mussels which have fixed themselves in their sockets. Nemesis thus, by a chance of anchorage, converts a favourite food into a permanent inconvenience.

Again, in connection with the pelagic food of fishes, it is a well-known fact that adult cod are extremely fond of sea-anemones,[2] and some of the rarest species may be procured in their stomachs, a feature by no means surprising when we remember that Abbé Dicquemare cooked and ate his sea-anemones with great relish, and wrote in their favour, as also did Mr. Gosse in our own country. Now, the pelagic young fishes, instead of roaming near

[1] A Discourse delivered by Prof. W. C. McIntosh, F.R.S., at the Royal Institution, on Friday, February 1, 1889.

[1] The fact that certain fishes feed on Infusoria has not been overlooked.
[2] A favourite bait for cod in some parts; and from the fact, amongst others, that star-fishes do not molest them on the hooks, no bait is more successful.

the bottom in proximity to the anemones fixed on the rocks, and running the risk of being themselves captured for food, find in the inshore waters in summer the larval *Peachiæ* in great numbers conveniently attached by the mouth to the little Hydromedusæ (*Thaumantias hemisphærica* and *T. melanops*) which occur in swarms in mid-water. Moreover, the somewhat larger young food-fishes (2 to 3 inches) show the same liking for the Cœlenterate group, by browsing on the zoophytes (*Obelia geniculata*) which cover the stones and rocks with feathery tufts, yet the zoophytes are not much the worse for this treatment, for they by and by shoot afresh, and clothe the area once more with dense forests. The rapidity with which such zoophytes grow is remarkable, though we must remember that in some cases the old stock naturally dies off after having produced swarms of pelagic young.

Under this rich food, the young fishes grow apace; head and eyes, mouth and accessory organs, body and fins—all rapidly increase; and the little fish, hatched in the spring, say from March to May, is soon in what is known as the post-larval stage—that is, has lost its yolk-sac, has assumed a more or less uniform tint, and has gill-fringes and teeth. It is about a quarter of an inch long, and is both active and intelligent, the large head and large eyes of the young food-fishes being at this stage specially conspicuous, and in marked contrast with such as *Cottus*. The marginal fin is quite continuous at a quarter of an inch, and the lancet-like termination of the caudal end of the body is noteworthy.

About this time the ventral fins of the young fishes first make their appearance, for hitherto they have managed to do without them. Moreover, these fins in some, such as the rockling and ling, undergo remarkable development, forming in the latter (Fig. 7) a pair of great ventral wings, conspicuously coloured yellow; yet in the adult (a ground-fish) they attain no greater dimensions than in the cod, both having at a certain stage soft, free filaments or tacile processes at the tip. The ventral fins in the post-larval rockling (Fig. 12) are equally large, the distal half being black,

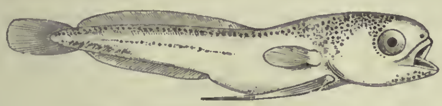


FIG. 12.—Post-larval rockling (enlarged).

so that at first sight the little fish when captured seems to possess a great ventral spine on each side. In the post-larval gurnard again, the huge pectoral fins form a drapery for the entire body when folded back, only the tip of the tail extending beyond them (Fig. 13). They are indeed proportionally as large as in the southern flying gurnards, but in these the fins reach full development only in adult life, while in the young stages they are comparatively small—exactly the reverse happening in the grey gurnard of our seas. The presence of the broad arches of pigment on the pectorals of several forms, such as the present species, green cod, and armed bullhead, is also an interesting feature. We have not yet read the riddle of all these changes, but in the ling the great ventral fins are probably connected with its roaming or pelagic life, and this explanation would also suit in the case of the rockling, both in their mature state seeking their food on the ground.

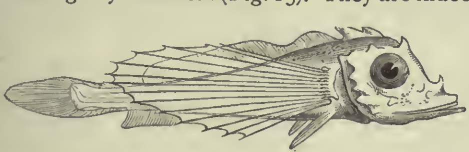


FIG. 13.—Post-larval gurnard (enlarged).

The little fishes at this stage are still more or less translucent, except in the region of the eyes, which are silvery, and on the parts where the pigment occurs. Moreover, their fondness for a minute reddish Copepod (*Calanus finmarchicus*), which occurs in myriads around them, gives the region of the stomach a faint pinkish hue from the translucency of the tissues. By and by, however, pigment appears, foreshadowing in the cod those peculiar squares which give the sides, at a somewhat later stage, their tessellated or tartan-like aspect. Besides, they are found nearer the bottom of the water, so that they can be captured in a naturalist's trawl with a fine gauze bag at the end. There is, therefore, a downward tendency as the little fishes get older and stronger, and thus in many cases a parallelism exists between them and the minute forms on which they prey, for the eggs rise on deposition toward the surface, where the helpless larvæ (or newly hatched young fishes) also often occur, and then they seek the lower regions of the water as their size increases.

There is much that is wonderful in such a life-history, especially in the metamorphoses or changes of form undergone by many of our best fishes, such as the flat fishes (Pleuronectidæ), which come out of the egg just like a haddock or cod, with an eye on each side, yet in after life have both eyes on the same side, as in Fig. 2. Nothing like this occurs in any of the higher vertebrates. Gradually during growth the body of the fish increases in depth (Fig. 14), the right or left eye passes over the ridge of the back to the opposite side (Fig. 15), while the creature, hitherto

FIG. 14.—Young "witch" (*Pleuronectes cynoglossus*) in the third stage (enlarged).

FIG. 15.—Young "witch" at a later stage, the left eye just appearing on the ridge of the head (enlarged).

pelagic, sinks deeper in the water and exhibits a tendency to lie on the side from which the eye has passed, and which gradually loses its dark pigment so as to become white.[1] It finally reaches the bottom, taking up its residence amongst the sand or sandy mud, and lying with the two eyes and the coloured side up, the white underneath. The mode by which the eye travels round has been a fruitful source of discussion with scientific men, and amongst these the names of Steenstrup, Malm, Schiödte, and Alex. Agassiz abroad, Wyville Thomson and especially Traquair in our own country, are well known. The fact is, two methods exist in Nature: in the one the eye travels over the ridge of the head, as just described in the flounder; in the other it traverses the soft and yielding tissues of the tiny fish, and so gains the other side. In *Plagusia*, the species in which the latter remarkable change occurs in the post-larval stage, the general tissues are so transparent that the creature in a glass vessel can only be noticed by the two apparently disembodied eyes, or by the gleam of light caused by its movements; and before the change ensues in its eyes it can look obliquely through its own body and see what passes on the other side.[2]

[1] The tardy disappearance of the pigment in some forms is interesting.
[2] Alex. Agassiz, Proceed. Americ. Acad. Arts. and Sci., vol. xiv. p. 8, 1878.

Up to this stage in the life-history of both round and flat fishes it will have been apparent that the efforts of man can have little effect on the vast multitudes of the eggs and minute fishes. His trawl sweeps beneath them, or they are carried harmlessly through its meshes. Not even in the case of a trawl blocked by a fish-basket and several large skate are any likely to occur. No example, indeed, was procured in the trawling expeditions for the Commission under Lord Dalhousie. The hooks of the liners are too large for the mouth at this stage, and hence they escape capture. Their small size and translucency also seem to afford protection in the case of predatory fishes of their own or other kinds, for they are rare, so far as present observation goes, in the stomach of any fish. Their great numbers are doubtless kept in check by some means, and we know that even jelly-fishes (*e.g. Pleurobrachiæ*) are very fond of post-larval fishes. It is only when they become somewhat larger that they are preyed on by their own and other species, and are swept up in thousands by the destructive shrimp-nets on our sandy shores.

While the little food-fishes are assuming the change of hue indicated in the preceding pages, they in many cases seek the inshore waters; at least systematic use of the mid-water and other nets proves that at certain seasons they are met with in large numbers at the entrance to bays or off-shore, and that a little later, in the case of the cod from the 1st of June onward, they are visible from the rocky margins. The coloration in this species (cod) is now beautifully tessellated, and they swim in groups, often in company with the young green cod, at the margin of the rocks at low water, and in the little tidal bays connected with rock-pools. The latter are often richly clothed with tangles, bladder-weed, red and green seaweeds, and the green *Ulva*, amidst the mazes of which the young fishes find both food and shelter, capturing the little Crustaceans (Copepods, Ostracods, and others) swimming there, and snatching the young mussels and minute univalve mollusks from the blades of the seaweeds. To the zoologist few sights are more interesting than to watch the little cod in these fairy lakes, as they swim in shoals against the current, balancing themselves gracefully in the various eddies by aid of their pectoral fins. In a mixed company, the young cod are easily recognized by their coloration, and the reddish hue of the occiput, for the blood-vessels there shine through the tissues, which generally are more translucent than in the green cod.

Prof. G. O. Sars considered that about this stage there was an intimate connection between them and the hordes of Medusæ (*Aurelia* and *Cyanea*) which abound in the inshore waters towards the end of summer. He thought the young cod approached the Medusa for the sake of the minute pelagic animals stupefied by its poisonous threads, and that the fish repaid this favour by picking off a parasitic Crustacean (*Hyperia medusarum*) which clings to the Medusa. Observations, continued for a long period in this country, show however that this connection is only casual and of very little importance, and that certain *Hyperiæ* are occasionally found in vast numbers in a free condition.

As the season advances, the young cod are joined off the rocky ledges by a few pollack and whiting, but not by the haddock, which appears to have certain social views of its own—keeping probably a little farther out. The size of this cod late in autumn, as in October, varies, some reaching 4 to 5 inches in length. Their food ranges from zoophytes to crustaceans, mollusks, and small fishes, and in confinement the larger are voracious, an example about 5 inches readily attacking a smaller (3 inches), and swallowing it as far as possible, though for some time a considerable portion of the body and tail of the prey projected from the mouth. Moreover, the tessellated condition becomes less marked, and as they approach 8 inches in length a tendency in some to uniformity of tint is noticeable. Many of those, however, that continue to haunt the rocky shores and the tangle-forests beyond low water still retain for some time mottled sides, and they are known by the name of rock-cod. Further, while their growth in the earlier stages is less marked, it is now very rapid—even in confinement. The exact rate of growth in the free condition in the sea is difficult to estimate, but the little cod of an inch and a half to an inch and three-quarters in June reach lengths varying from 3 to 5 inches in autumn, and in the tanks of the laboratory, specimens 5 inches in August attain 8 inches the following March. At Arendal, in Norway, where opportunities for watching the growth of cod in confinement have been supplied with a liberality yet foreign to our country, Dannevig found that the cod of 3 mm. in April reached only 15 mm. in June, a length somewhat at variance with the condition as above stated on our shores. In July they measured 2 inches, in September 3½ inches, and in October about 4½ inches. The second year they attained 14 to 16 inches in length. In artificial circumstances, as well as in nature, it is found that great variation exists in the sizes of the young fishes of the same age, and this variation would not seem to be related to temperature.

At the stages just mentioned they now come under the notice of both liner and trawler, for young cod 5 or 6 inches in length occasionally take a haddock-hook, and those somewhat larger (9 to 18 inches) occur in certain hauls of the trawl, especially off a rocky coast like that of Aberdeenshire, south of Girdleness, as well as on the hooks of the liners on rough ground. Special trips, indeed, were, and perhaps are, made by the liners for the capture of these young cod (termed codling), and thus their numbers are kept in check.

So far as present observations go, therefore, the young cod in a free condition reach the length of from 4 to 10 inches the first year, while in the second they attain from 10 to 20 inches or more. It probably takes 3 or 4 years (and this is the original opinion of Sars) or more, to reach full maturity, and a length of 3 feet or upwards; though he mentions having seen young cod a foot in length, with mature roe and milt in the fish-market of Christiania. These, however, were probably abnormal examples.

Let us now glance at the condition in the whiting. Its earlier post-larval stages immediately following those observed in the tanks at the laboratory (for we failed to rear them) are even now somewhat obscure, but they probably approach those of allied forms such as the cod and haddock. The characteristic nature of the larval pigment, however, would lead to the belief that perhaps in the brighter tints (*e.g.* yellow), differences may occur. Such, however, are lost before they come under observation; for all these delicate and minute forms are dead before reaching the deck, and indeed considerably altered. The pressure to which they are subjected in the large mid-water net by the crowds of Hydromedusæ and Ctenophores alone would suffice for this, and the handling of the heavily laden net increases the dangers to forms so fragile. One about 12 mm. shows in spirit the dorsal and anal fins outlined though not separated from each other, and permanent rays occur in them and in the caudal. Minute ventrals are present, while the pectorals form large mobile fans. Groups of black pigment-corpuscles are distributed along the base of the dorsal and anal fins and over the brain, and a similar series occurs along the ventral median line of the abdomen. The sides have these blackish pigment-corpuscles more generally distributed than in the cod. No barbel is noticeable. When a little longer (15 mm.), the species is distinguished from the young cod by a more abundant distribution of black pigment-specks along the sides of the body and on the fins, and by the greater length and diminished depth of the first anal fin. The median line of pigment still runs along the ventral surface of the abdomen. At 20 mm. the characters that distinguish it from the cod of the same size are better marked, viz. the distribution of dense blackish pigment along the base of the dorsal fins; and it soon spreads downward over the sides. The first anal fin assumes the character of the adult, and a minute papilla indicates a barbel. Between the stage just mentioned and a length of 28 mm. a decided change in the dense dorsal pigment takes place, viz. a tendency to form separate groups or touches (Fig. 16). These differ from

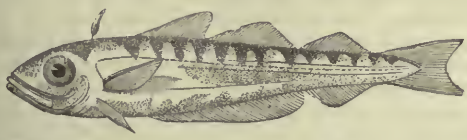


FIG. 16.—Young whiting, with serrated dorsal pigment-band and parasitic *Chalimus*.

the cod in being confined to the dorsal region, though a few bars occur at the base of the tail. The fish is also now minutely flecked, all over the head, sides, snout, and fins with black pigment, and its general outline approaches that of the adult. It is at once distinguished from the young cod by the shortness of the snout, irrespective of the features already pointed out, by the coloration, and by the shape of the first anal fin.

The differentiation of the two species, viz. the cod and the whiting, is very marked in spirit at the length of 34 mm. In the whiting the median dorsal fin is less abruptly elevated than in the cod, and the first anals diverge widely, the elongation of the latter being probably connected with the abbreviation of the abdomen. The body of the whiting is more plump and neatly rounded than in the cod, which is flatter and has generally a more prominent abdomen. The pigment-specks closely cover the sides of the body in the whiting, as well as the membranous webs of the dorsal fins, and are continued on the head. The pigment at the base of the caudal rays is more distinct in the whiting, and the lancet-like caudal termination of the body is longer in this species. The myotomes are coarser in the cod, and the surface has little of the dappled silvery sheen of the whiting. The chromatophores are larger in the cod, and are grouped in blotches over the surface, with intermediate pale patches, and the shoulder and head have much less pigment than in the whiting. Both the pectoral and ventral fins of the cod are shorter than those of the whiting. The snout in the latter is shorter and broader as well as deeper, and the short sub-mental papilla is in contrast with the long barbel of the cod of the same length. The whiting, produced from an egg of larger size, would appear to attain a plump body and finished outline sooner than the cod.

The foregoing stages are very abundant in autumn in the deep water off the Isle of May and the mouth of the Forth, but they also appear west of Inchkeith in the latter estuary. They are indeed more characteristic of the former region, as far as present observations go, than of the shallow water of the open bays, such as St. Andrews, though on reaching a somewhat larger size they are quite common in the latter expanse. Both they and the cod in these early stages are infested by a Crustacean parasite (*Chalimus*), which adheres to various parts of the head and body, just as the larval *Anceus* tenaciously attacks the young flounders in tidal harbours and inshore grounds.

The young whiting at a later stage (3 to 5 inches) joins the young cod at the margins of the rocks, and forms independent shoals in tidal harbours, as well as occurs some distance off shore, being frequently got in the mid-water net in the deeper water. Towards the latter size (6 to 7 inches) it readily takes the hooks of the liner, and in certain bays the multitudes of young whiting prove an inconvenience to the fishermen. As it increases in size great shoals are formed in the offing, though a few small are almost always found in inshore waters.

The young round fishes, such as cod, haddock, and whiting, of similar or nearly similar size, seem respectively to herd together. Thus it happens that in certain hauls of both liners and trawlers the majority agree in size. This is well known to the liners, who in former days specially sought out the young cod as already indicated. The same feature is observed in many other fishes, and probably conduces to their safety.

So far as known, the adult fishes of the three kinds specially alluded to in the preceding paragraph (viz. cod, haddock, and whiting) follow no very definite law in regard to migrations, if we except the apparent congregation in certain regions during the spawning season, as pointed out, for instance, by Sars, off Lofoten, where they occur in vast numbers from January to March. In our own country, again, the appearance of shoals of haddocks and whiting in certain localities is another example. How far such multitudes, however, are influenced by the abundance of food is still an open question. In British seas the herring is the main cause of these congregations in the cod and haddock; the former chiefly pursuing the fishes, the latter their eggs. In the same way, the abundance of Norway lobsters and similar food on the grounds called banks exercise considerable influence on the presence of cod.

It has already been pointed out, however, that in their young stages certain migrations do occur. Thus the post-larval cod by and by seeks the Laminarian region, while the older forms for the most part tend to go seaward. The same occurs even in a more pronounced manner with the ling, the adults of which as a rule are found in deep water. The pelagic post-larval ling seeks downwards as it grows, and is seldom found near the shore till it attains the length of 6 or 7 inches—in short, until it is barred with pigment. As it increases in size it migrates seaward. Similar features are noticed in the plaice. As observed in the trawling expeditions of 1884, only large plaice as a rule are procured in deep water off the east coast, while the sandybays abound with those ranging from 11 inches downward, and none of the females of which appear to be mature. Multitudes of little plaice haunt the margins of these sandy beaches, but it cannot be said that forms which have the length, for example, of 3 inches, are confined to any particular line drawn across a bay, for small forms (2 to 4 inches) occur in hauls all over such a bay as that of St. Andrews. Small turbot and halibut in the same way are often found in the shallow bays, while the large adults are inhabitants of the deeper water. Such would not, however, seem to be the case with certain skate, very large adults of which occur in the shallow water of the sandy voes in Shetland.

On the other hand, the witch (*Pleuronectes cynoglossus*) keeps to its special areas, both as regards the young and the adult condition, so that the movements of eggs, larval and post-larval forms are circumscribed; and the same would seem to be the case with the topknot (*Zeugopterus*) and sail-fluke (*Arnoglossus*). The dab (*Pleuronectes limanda*), again, is found in all stages both in comparatively deep and comparatively shallow water.

Almost all our valuable food-fishes, therefore, are produced from minute pelagic eggs, the enormous numbers of which provide for a vast increase and wide distribution of the species; yet it cannot be said that this habit alone provides for their multiplication when the case of the herring with its demersal eggs, fixed firmly to the bottom, is considered. It has to be borne in mind, however, that the larval herring immediately mounts upward toward the surface as soon as its strength suffices.

Many striking changes occur during growth, both in external form and coloration, but it is difficult at present to lay down any general law that would apply to all cases, though those in which certain migrations take place during growth show such changes very prominently. The young round fishes by and by roam about the sea in shoals, led hither and thither mainly by the presence of food; though in the case of the larger and adult forms, safety or freedom from molestation may have some influence. Though so minute on escaping from the egg, their growth is, by and by, rapid, and the duration of life in such as the cod is considerable. Abundance of food, more than any special instinct, would appear to be the main cause of their migrations in the adult or semi-adult state, and that food is as varied as their haunts; in short, it embraces every sub-kingdom up to their own, for fishes and their eggs form a large share of their diet.

There would be little difficulty in adding to the sea great numbers of larval forms of any species of which eggs can be procured: yet if a few adults can be obtained in such waters at the proper season it is still an open question whether the natural process with its surroundings would not be more successful.

In the foregoing remarks I have but touched on a few of the leading features of the life-history of a food-fish; for the subject is one of vast extent, and some of the points embraced in it are by no means easily solved. We have only earnestly entered on the study of the subject in this country within the last few years, and much yet remains to be done, even in some of the most common marine fishes. However, the zoological investigator is here stimulated by the fact that all his labours directly bear on the public welfare, for it need hardly be pointed out that a thorough knowledge of the development and life-histories of our food-fishes is the first step to sound legislation and effective administration. The State has in past years spent princely sums on more or less pure science, as in the memorable voyage of the *Challenger*. There can be no doubt that at the present moment the public interests demand a searching and long-continued inquiry nearer home, viz. the exhaustive investigation of all that pertains to the food-fishes of our shores, since the problems connected therewith affect the prosperity of so large a portion of the population.

ON THE MENTAL FACULTIES OF ANTHROPOPITHECUS CALVUS.[1]

THE female Chimpanzee which has now been in the Society's Menagerie for nearly six years has attracted general notice, not only on account of her peculiar zoological characters, but perhaps still more on account of her high intelligence. This is conspicuously displayed by the remarkable degree in which she is able to understand the meaning of spoken language—a degree which is fully equal to that presented by an infant a few months before emerging from infancy, and therefore higher than that which is presented by any other brute, so far, at least, as I have met with any evidence to show. Nevertheless, the only attempts that she makes by way of vocal response are three peculiar grunting noises—one indicative of assent or affirmation, another (very closely resembling the first) of dissent or negation, and the third (quite different from the other two) of thanks or recognition of favours. In disposition she is somewhat capricious, though on the whole good-humoured, fond of her keepers, and apparently never tired of a kind of bantering play which off and on they keep up with her continually. By vocalizing in a peculiar monotone (imitative of the beginning of her own "song"), they are usually able to excite her into the performance of a remarkable series of actions. First, she shoots out her lips into the well-known tubular form (depicted in Darwin's "Expression of the Emotions," p. 141), while at the same time she sings a strange howling note interrupted at regular intervals; these, however, rapidly become shorter and shorter, while the vocalization becomes louder and louder, winding up to a climax of shrieks and yells, often accompanied with a drumming of the hind feet and a vigorous shaking of the network which constitutes her cage. The whole performance ends with a few grunts.

A year or two ago it occurred to me that I might try some psychological experiments on the intelligence of this animal. The circumstances in which she is placed, however, did not prove favourable for anything like systematic instruction. Being constantly exposed to the gaze of a number of people coming and going, and having her attention easily distracted by them, the ape was practically available for purposes of tuition only during the early hours of the morning, before the Menagerie is open to the public; and, as a rule, I did not find it convenient to attend at that time. Therefore, the results which I am about to describe do not in my opinion represent what might fairly have been expected under more favourable conditions: if the Chimpanzee could have been kept as a domestic pet for a few months (as I kept the Cebus kindly lent me for the purposes of psychological observation by this Society), there can be no doubt that many much more interesting results might have been obtained. Nevertheless, it appears to me that even those which thus far have been obtained are worthy of being placed on record; and although some of them have already been published a few months ago in my work on "Mental Evolution in Man," since that time some further progress has been made; and therefore in the present paper I will state together all the facts which have been hitherto observed.

Having enlisted the intelligent co-operation of the keepers, I requested them to ask the ape repeatedly for one straw, two straws, or three straws. These she was to pick up and hand out from among the litter in her cage. No constant order was to be observed in making these requests, but, whenever she handed a number not asked for, her offer was refused, while, if she gave the proper number, her offer was accepted, and she received a piece of fruit as payment. In this way the ape was eventually taught to associate these three numbers with their names. Lastly, if two straws or three straws were demanded, she was taught to hold one straw or two straws in her mouth until she had picked up the remaining straw, and then to hand the two straws or the three straws together. This prevented any possible error arising from her interpretation of vocal tones—an error which might well have arisen if each straw had been asked for separately.

As soon as the animal understood what was required, and had learnt to associate these three numbers with their names, she never failed to give the number of straws asked for. Her education was then extended in a similar manner from three to four, and from four to five. Here, for reasons to be presently stated, I allowed her education to terminate. But more recently one of the keepers has endeavoured to advance her instruction as far as ten. The result, however, is what might have been anticipated. Although she very rarely makes any mistake in handing out one, two, three, four, or five straws, according to the number asked for; and although she is usually accurate in handing out as many as six or seven; when the numbers eight, nine, or ten are named, the result becomes more and more uncertain, so as to be suggestive of guess-work. It is evident, however, that she understands the words seven, eight, nine, and ten to betoken numbers higher than those below them; for if she is asked for any of these numbers (*i.e.* above six), she always gives some number that is above six and not more than ten; but there is no such constant accuracy displayed in handing out the exact number named as is the case below six. On the whole, then, while there is no doubt that this animal can accurately compute any number of straws up

[1] Paper read before the Zoological Society on June 4, 1889, by Prof. George J. Romanes, F.R.S.

to five, beyond five the accuracy of her computation becomes progressively diminished.

It is to be noticed that the ape exhibits some idea of multiplication; for she very frequently (especially when dealing with numbers above five) doubles over a long straw so as to make it present two ends, and thus to appear as two straws. Any of the comparatively rare errors which she now makes in dealing with numbers below six are almost invariably due to her thus endeavouring to duplicate her straws. In this connection it is to be remembered that, owing to the method above described (whereby the ape is required to place each straw separately in her mouth until the sum asked for is completed), when any high number is demanded a considerable tax is imposed upon her patience; and, as her movements are deliberate while her store of patience is but small, it is evident to all observers that the doubling of the straws is intended to save trouble by getting the sum completed with greater rapidity than is possible when every straw is picked up separately. Of course we do not recognize these doubled straws as equivalent to two straws, and therefore the persistency with which she endeavours to palm them off as such is the more noteworthy as evidence of her idea of multiplication. Moreover, I am disposed to think that the uncertainty which attends her dealing with the numbers six and seven is more largely due to her losing patience than to her losing count; although after seven I believe that her computation of the numbers themselves becomes vague, or merged in a merely general idea of many. It may also be stated that, while picking up the straws and placing them in her mouth, she looks only at the straws themselves and not at the person who asks for them: therefore she is certainly not actuated in her responses by interpreting facial expression, unconscious gesture, &c., as is no doubt the case with many dogs which on this account are sometimes accredited by their owners with powers of "thought-reading." It is needless to add that, after asking for the number of straws required, we remain silent till the ape has handed them out.

It is not necessary—indeed it would be unreasonable—to suppose that in this process of "counting" the ape employs any system of notation. We know from our own experience that there is counting and counting, *i.e.* distinguishing between low numbers by directly appreciating the difference between two quantities of sensuous perception, and distinguishing between numbers of any amount by marking each perception with a separate sign. The extent to which the former kind of computation can be carried in the case of man has been made the subject of a careful research by Prof. Preyer, of Jena (*Sitz. Ber. d. Gesell. f. Med. u. Naturwiss.*, 1881). His experiments consisted in ascertaining the number of objects (such as dots on a piece of paper) which admit of being simultaneously estimated with accuracy, and it was found that the number admits of being largely increased by practice, until, in the case of some persons, it may rise to more than twenty. But of course in the case of a brute it is not to be expected that such a high degree of proficiency even in this non-notative kind of "counting" should be attainable. The utmost that could here be expected is that a brute should exhibit some such level of ability as is presented by a young child, or by those savages whose powers of accurate computation do not appear to extend further than numbers which we write as units.[1] It was in view of such considerations that I did not attempt to carry the education of this ape beyond the number five; and the result which has attended subsequent endeavours to teach her numbers as high as ten is, as previously remarked, exactly what might have been anticipated. It may here be added that in the only records with which I am acquainted of animals exhibiting any powers of numerical computation, these powers have not extended beyond the number five. Thus, for instance, in his well-known account of these powers as presented by rooks, Leroy says:—"To deceive this suspicious bird, the plan was hit upon of sending two men into the watch-house, one of whom passed out while the other remained to shoot the bird on returning to her nest; but the rook counted and kept her distance. Next day three went, and again she perceived that only two returned. In fine, it was found necessary to send five or six men to the watch-house in order to throw out her calculations."[1] Again, Houzeau tells us that mules used in tramways at New Orleans have to make five journeys from one end of the route to the other before they are released, and that they make four of these journeys without showing any expectation of being released, but begin to bray towards the end of the fifth.[2] Lastly, the keeper of the eared seals now in the Menagerie has recently taught one of these animals to "count" as far as five His method is to throw pieces of fish in regular succession, which the animal catches one by one. He throws them in series of fives, and, before the commencement of any series, he tells the seal to miss the first, the second, the third, the fourth, or the fifth, as the on-lookers may dictate: the seal thereupon makes no attempt to catch the member of the series thus verbally indicated. It is only a day or two ago, however, that I witnessed this performance, and as yet I am not satisfied that the seal really "counts," because it appears to me probable that the keeper may unintentionally throw, with some slight difference in his manner of throwing, the piece of fish which he expects the seal to miss, and that it is really this slight difference in the manner of throwing which the seal perceives and acts upon. Therefore, I intend to get an arrangement fitted up whereby the pieces of fish shall be thrown mechanically. But, whatever the result of this experiment may be, I think there can now no longer be any question that it lies within the capacity of animal intelligence to "count" correctly (in the sense already explained) as far as five, and even to show a well-marked appreciation, although progressively a more and more uncertain one, of numbers lying between five and ten.

The only other direction in which I have thus far subjected the Chimpanzee to psychological experiment has been in that of attempting to teach her the names of colours. It appeared to me that if I could once succeed in getting her thoroughly well to know the names of black, white, red, green, and blue, a possible basis might be laid for many further experiments wherein these five colours could be used as signs of artificially associated ideas. The result, however, of attempting to teach her the names of colours has been so uniformly negative, that I am disposed to think the animal must be colour-blind. It is perhaps desirable to state the facts which have led me to entertain this as their most probable interpretation.

The method adopted in these experiments was to obtain from the importers of Oriental matting a number of brightly and uniformly coloured pieces of straw—each piece being either white, black, red, green, or blue. Taking the straws two by two of different colours, on each occasion the ape was invited to choose the straw of the colour named from the one whose colour was not named, and, of course, on choosing correctly she was rewarded with a piece of fruit. In this way she quickly learnt to distinguish between the white straws and the straws of any other colour; but she never could be taught to go further. Now the distinction between the white straws and the straws of any other colour is a distinction which could have been drawn by an eye that is colour-blind; and from the fact that the ape is always able to perceive this distinction (she will search long and patiently for a straw of any colour when told that it occurs somewhere in the general litter of white straws constituting her bed,

[1] See, for instance, Galton, "Tropical South Africa," p. 213

[1] "Letters, &c." [2] "Fac. Ment. des Anim.," tom. ii. p. 207.

and eventually picks it out), while she cannot be taught to distinguish any of the others, I conclude that her failure in this respect is not due to any want of intelligence, but to some deficiency in her powers of colour-perception.

NOTES.

THE annual meeting for the election of Fellows of the Royal Society was held at the Society's rooms in Burlington House, on June 6, when the following gentlemen were elected:—John Aitken, Dr. Edward Ballard, Alfred Barnard Basset, Horace T. Brown, Latimer Clark, Prof. David Douglas Cunningham, Lazarus Fletcher, William Botting Hemsley, Charles Thomas Hudson, Prof. Thomas McKenny Hughes, Edward B. Poulton, Prof. William Johnson Sollas, Charles Todd, Herbert Tomlinson, Prof. Gerald F. Yeo.

THE statue of Le Verrier is to be unveiled in the court of the Paris Observatory on June 25.

HERR VICTOR APFELBECK, the entomologist, will shortly start, in behalf of the Bosnian Government, on a journey of research in Herzegovina. Last year he discovered in Southern Bosnia five new species of eyeless cave beetles, and his investigations excited much interest among entomologists.

ACCORDING to the *British Medical Journal*, the programme of the Leeds meeting of the British Medical Association in August next "is developing in such manner as to afford the ample promise of a meeting of great scientific as well as social interest, and one which will be worthy of the traditions of this great medical centre."

MR. JOHN FREDERICK LA TROBE BATEMAN, F.R.S., died on Monday morning at Moor Park, Farnham, at the age of seventy-nine, after a severe illness. Mr. Bateman was well known as the engineer who supplied Glasgow with water from Loch Katrine.

THE death of Eugen Ferdinand von Homeyer, the eminent ornithologist, is announced. He had been President of the Ornithological Society at Berlin, was the author of several works, and possessed the largest existing collection of European birds. He was born at Herdin, near Anklam, in 1809, and died at Stolp, in Prussia, on June 1.

INFORMATION has been received in Berlin of the death of Dr. Bernhard Weissenborn, the zoologist to the German Cameroons Expedition, from a fever contracted through the hardships of the work and the bad climate.

GERMAN papers record the death of Dr. C. Jessen, the naturalist, formerly Professor at Greifswald, and lately at the Berlin University. He was sixty-eight years of age.

AT a meeting of the Royal Horticultural Society on Tuesday, a paper on orchids was read by Mr. H. Veitch. In the discussion which followed the reading of this paper, various speakers referred with regret to the death of Prof. Reichenbach, and to the strange provisions of his will, by which botanists of the present generation will be prevented from studying his fine collection of orchids. Mr. Thiselton Dyer invited those interested in the nomenclature of orchids to put themselves in communication with the Kew Herbarium, and it was stated that Messrs. Veitch and Sander could furnish many duplicates of the examples which were to be locked up under the will of Reichenbach. Sir T. Lawrence spoke of an orchid which had been in this country to his knowledge for fifty years.

THE June number of the *Kew Bulletin* opens with an instructive paper on Jamaica cogwood. This is one of the most valuable timber-trees in Jamaica, yet until recently its flowers and fruit had not been received in this country, so that, as the writer points out, the position of the plant in botanical classification had been left in doubt. Good herbarium specimens, including flowers and fruit, have lately been sent to Kew by Mr. W. Fawcett, Director of Public Gardens and Plantations in Jamaica; and from this material Prof. Oliver has determined the cogwood to be a species of *Zizyphus*, a genus not previously recorded from Jamaica. *Zizyphus* is the Jujube or Lotus genus of *Rhamneæ*, and the fruits of several species, such as *Z. vulgaris* and *Z. Jujuba*, have an agreeable flavour, and are commonly eaten. Besides this paper, there are contributions on cocoa-nut coir from Lagos, a wheat pest in Cyprus, patchouli, P'u-êrh tea, and agricultural industries at the Gambia.

WE take the following from *Allen's Indian Mail*:—"The appointment of Mr. A. Hartless from the Royal Gardens, Kew, to fill the vacancy in the staff of the Botanic Gardens at Shippur has given much satisfaction. This gentleman is a first-class botanist, and will no doubt contribute hereafter many original and important observations on the flora of India."

IN addition to the papers announced to be read at the ordinary meeting of the Royal Meteorological Society on June 19, a communication will be made on the recent thunderstorms, and a number of photographs of lightning will be exhibited.

A VIOLENT shock of earthquake, accompanied by local subterranean rumblings, was felt at Brest on June 7 at a quarter past one o'clock, its direction being from north to south. The shock is said to have resembled the vibration caused by the firing of a gun of large calibre. On the same day a shock of earthquake was felt at New Bedford, in Massachusetts.

ON April 13 and 14 a volcanic eruption occurred on Oshima Island, Japan. It is said that upwards of 300 houses were destroyed, and that 170 persons were killed by being buried beneath the ruined buildings.

ACCORDING to the *Japan Weekly Mail*, an earthquake of a most unusual character was recorded at 2h. 7m. 41s. p.m., on Thursday, April 18, in the Seismological Observatory of the Imperial University, Tokio. The peculiarity lies, not in its violence, but in the extreme slowness of its oscillations. The beginning of the shock had all the characteristics of the ordinary earthquake, but gradually the motion augmented, until at a certain stage of the shock it reached 17 millimetres, but the ground swayed so gently that the house did not vibrate visibly, nor were the senses alive to it. It took from four to seven seconds to complete one oscillation—a most unusual phenomenon, and one never before noted in the Observatory. The motion was almost entirely confined to the horizontal plane, and mostly south to north, but there were a few vertical motions of equally slow periods. This state of things lasted for 10 minutes 36 seconds. Prof. West, of the Engineering College, observed the water in a small pond to oscillate gently from north to south. At one time the water-level fell about 2 inches on one side of the pond, and exposed the bank, while, a few seconds later, the water immersed it nearly to the same depth, exposing the opposite bank, and this process continued for a quarter of an hour. "Slow oscillations of this nature have been called earth-pulsations, and these usually take place where there is a destructive earthquake or a submarine disturbance going on at a great distance. Earth-pulsations are known to have caused slow oscillations of the water in lakes. From this fact it may not be unreasonable to conjecture that a terrestrial or submarine agitation of unusual magnitude has taken place somewhere. The authorities of the Science College have sent to the Hydrographical Bureau of the Naval Department, asking for information as to the state of the tide and seas. It may be as well to remark that it is not certain whether the maximum motion of 17 millimetres, as given by the seismograph, is perfectly accurate, as it is very difficult to measure slow oscillation like this with absolute certainty." It is now known as a fact that Vries Island, outside Yokohama Bay, and possibly sixty miles off, was in a state of violent volcanic eruption.

THE Admiralty has published an interesting Report on the bore of the Tsien-Tang Kiang, by Captain W. U. Moore, of H.M.S. *Rambler*, as a fitting termination to a long series of tidal observations made on that vessel in Chinese waters. Scarcely anything was before known about this phenomenon, although it occurs twice a day, seventy miles from Shanghai. The bore was found to originate, not at the mouth of the river, as was expected, but twelve or fifteen miles outside it. Captain Moore states that the bore cannot be accurately described as a wave, there being no undulation, nor any depression after it has passed. It is divided into two branches, which join together four miles from Haining, making a continuous white line two miles in length. It shortly afterwards contracts in width, and increases in speed and height, rising 8 to 11 feet high, and travelling between 12 and 13 knots an hour. The three cutters employed in making the observations were at times in considerable danger, and the Hydrographer pays a high compliment to the skill with which the boats were brought safely out of their dangerous situation.

THE meteorological observations for the year 1888, made at the Rousdon Observatory, Devon, under the superintendence of Mr. Cuthbert E. Peek, have been published. They are a continuation of those issued last year. The instruments continue to perform to Mr. Peek's satisfaction, and have been regularly read by his assistant, Mr. C. Grover. The observatory is a second order station of the Royal Meteorological Society.

MR. THOMAS SCOTT, of the Scientific Department, Scottish Fishery Board, recently fertilized ripe ova of the common gurnard (*Trigla gurnardus*) with milt of the whiting (*Gadus merlangus*). Segmentation soon set in, and development proceeded for about a day and a half; but the ova then gradually sank, showing that death had supervened, this being attributed to an imperfect supply of fresh sea-water. An attempt to fertilize gurnard ova with milt of the common dab (*Pleuronectes limanda*) failed; but ova of the lemon sole (*P. microcephalus*) were successfully fertilized by milt of the same species, and floated buoyantly.

A SHARK 10 feet long and 4 feet in girth was caught on the morning of June 7, about twenty-four miles south-east of Ventnor by the mackerel nets of the smack *Pioneer*, of Brighton. It has three rows of teeth, and is supposed to be three years old.

TRACES of glacial action have been discovered on the Thomasberg, which is over 800 metres high, near St. Margarethen, in the Rosenthal in Carniola.

MESSRS. MACMILLAN AND CO. have issued a new edition of Prof. T. H. Core's "Questions on Stewart's Lessons in Elementary Physics." The late Prof. Balfour Stewart, writing of the first edition of this useful little volume, said that Prof. Core had made his questions "at once simple and suggestive, leading on in some cases to higher results, so as to encourage students to proceed with the subject."

ALL students of ethnology and anthropology will welcome the first number of *Veröffentlichungen* from the Berlin Museum für Völkerkunde. This periodical, which is clearly printed on good paper, takes the place of the *Original-Mittheilungen aus der Ethnologischen Abtheilung der Königlichen Museen*. The first number consists of plates illustrating American antiquities, with full descriptions and explanations. In some instances analogous objects from other parts of the world are represented along with those from America. The text is by Dr. Uhle, and Dr. Bastian contributes a brief prefatory note.

AN interesting paper on Palæolithic man in America, by Mr. W. J. McGee, of the United States Geological Survey, has been reprinted from the *Popular Science Monthly*. Mr. McGee holds that there is definite and cumulative evidence of man's existence in America during the latest ice epoch, with a strong presumption against an earlier origin than the first Quaternary ice-invasion; and that the primitive American "haunted the ice front rather than the fertile plain, and must have been hunter or fisherman."

AMONG the antiquities recently acquired by the Christiania Museum are some from the middle Iron Age, found in two barrows at Larvik. They consist of fragments of a lance, a shield with iron handle, a pair of shears or scissors, and a buckle of silver, besides a number of vessels, among which the most remarkable is a glass beaker, ornamented with threads of glass fused on to the exterior, a wooden bucket caulked with tar, and many urns. Among the latter is a large handsome one with a long neck. The graves in the barrows were made of stones. On a farm in the parish of Tjölling, also on the west coast of the Christiania fjord, a barrow, which had been formerly disturbed, has been excavated. Round it is a ring of raised stones. It dates from the early Iron Age. On the eastern and western side a *Bautasten*, or memorial stone, is raised. The funeral chamber is built of stone. Only three buckles of bronze, with silver ornaments, a plain ring made from an alloy of gold and silver, and the jaw-bone of a man with teeth remaining, were found. The body had not been burned. A yard further to the east a grave with calcined human remains was also found.

THE fourth issue of the *Jahrbuch der Naturwissenschaften* has just made its appearance. It is published by the Herderschen Verlagshandlung at Freiburg im Breisgau, and it remains under the editorship of Dr. Max Wildermann. It contains about 570 octavo pages, with an introduction. The subdivisions are under the control of different competent authorities. The section on physics occupies seventy-six pages, and is under the care of the editor; chemistry, with forty-six pages, and several sub-heads, under that of Dr. Hovestadt; applied mechanics, forty-six pages, under Dr. van Muyden; astronomy, thirty pages, under Dr. Franz; meteorology, under Dr. Pernter, forty-four pages; zoology, under three different editors, thirty-two pages; and similarly with botany, forestry, and agriculture, mineralogy and geology, anthropology, physiology, medicine and sanitary matters, geography, and ethnography. An appendix contains obituaries of eminent scientific men, and a report of the proceedings of the sixty-fourth meeting of the Association of German Naturalists and Physicians.

NAPHTHA is now much used as fuel in Middle Russia. Last year, 880,000 tons of it were sent up the Volga for fuel purposes; and it is expected that the export for the same purpose will this year reach no less than one million tons.

THE province of St. Petersburg is very rich in marshes covered with a thick carpet of vegetation, which conceals water to the depth of several feet—sometimes 25 feet and more. Small lakes and branches of rivers are continually being transformed into such marshes, and M. Tanfilieff, who has studied the way in which the transformation goes on, comes to the following conclusions (*Mémoires* of the St. Petersburg Society of Naturalists, vol. xix.). The pioneers of the transformation of a lake into a marsh invariably are flowering plants, such as *Menyanthes*, *Comarum*, *Cicuta*, *Equisetum*, *Carices*, and the like. Their roots and underground stems make a thickly-woven floating carpet, which soon totally conceals the water. The *Sphagnum* invades this floating carpet, while the water beneath becomes filled with *débris* of decaying plants, transformed later on into peat-bog. In shallow basins the transformation goes on at a much speedier rate, as their bottoms are invaded by plants like *Phragmites* and *Scirpus lacustris* which reach a considerable height, and thus supply, after their decay, a good deal of additional material for the filling up of the basin. A mass of smaller plants, such as *Lemna*, *Hydrocharis*, *Callitriche*, *Utricularia*, *Hypnum fluitans*, and several others, usually grow also amidst the rushes. Of course, the streamlets which flow into the basin contribute also to fill it up by bringing in sand and loam. As soon as the floating carpet has reached a certain thickness, and the *Sphagnum* has still more increased its bulk, various plants, such as *Drosera*, *Vaccinium*, *Eriophorum*, the dwarf birch, and other bushes, begin to grow upon it, although the space beneath still remains filled with water. As the *Sphagnum* does not grow upon ponds containing a chalky water, its place in such ponds is mostly taken by the *Hypnum*, and in these cases a variety of other plants, such as *Typha*, *Stratiotes*, *Butomus*, *Ranunculus divaricatus*, and *Chara fragilis*, make their appearance. As to the *Sphagnum*, it invades wet meadows as well.

AT a recent meeting of the French Academy of Sciences, M. de Malarce, speaking of the extension of the metric system of weights and measures, gave some interesting figures. In 1887 the aggregate population of the countries in which the metric system was compulsory was over 302,000,000, being an increase of 53,000,000 in ten years. In 1887, in countries with a population of close on 97,000,000, the use of the system was optional; and the countries where the metric system is legally admitted in principle and partially applied (as in Russia, Turkey, and British India) had in 1887 a population of 395,000,000, being an increase of 54,000,000 in ten years. The increase is due to the growth of population in the countries which had already adopted the system, and to its adoption by new countries. The systems of China, Japan, and Mexico, are decimal, but not metric. The metric system is thus legally recognized by 794,000,000 of people, and the three last-named countries have a population of about 474,000,000. So that only about 42,000,000 of inhabitants of the civilized world have systems which are neither metric nor decimal.

SIR ARTHUR NICOLSON, the British Consul at Buda-Pesth, in his last Report on Hungary, referring to technical education in that country, says that it will afford an indication of the attention which is being paid to this important question to instance the steps which have been taken in Buda-Pesth in regard to primary technical education. By paragraph 80 of the Trade Law of 1884, every *commune*, where there are fifty or more apprentices, is bound to provide for their education, and to afford special courses of instruction. The apprentice schools in Buda-Pesth contain a preparatory class, provide a course of three years, and are chiefly destined to educate apprentices for the higher trade schools. Each district of the town must have at least one apprentice school. No class is to comprise more than fifty pupils, or at most sixty pupils; and should the number of pupils be larger, parallel classes can be established. A pupil passes at the end of each year into a higher class if he can show proficiency and good progress. Theoretical instruction is given six hours in the week, and drawing and modelling are taught five hours weekly, on Sundays. The first schools were established in 1887, and numbered 12 with 125 teachers. There were 42 classes, or, including the parallel classes, 93, attended by 5173 pupils. In 1888 the number of schools had risen to 16, the number of classes to 127, the staff of teachers 151, and the number of pupils to 6459. In the other towns and counties of Hungary there were 229 apprentice schools, with 1237 teachers, and 38,081 pupils. For all these schools, including those of the capital, the *communes* contribute in florins 214,302; private individuals, 1387; Chambers, 680; counties, 9080; State, 35,806; fees and fines, 129,488; making a total of 390,843 florins.

THE British Consul at Ancona, in his last Report, refers to a School of Practical Agriculture established in Fabriano in 1882. It is subsidized by the Government, the province of Ancona, the municipality of Fabriano, and the local Chamber of Commerce. The school has a Director, two Professors, and a Teacher of Practical Agriculture. The course of study is spread over three years as follows: first year, Italian, geography, elements of natural history, elementary arithmetic, agronomy, and writing; second year, Italian, geography, elements of natural philosophy and chemistry, agriculture, and rural accounts; third year, horticulture, rural direction and management of a farm, technical agriculture, and arithmetic. The school at present has thirty-six scholars, of whom nineteen are in the first year, nine in the second, and eight in the third. Of these, twelve are agriculturists, ten sons of land stewards, eleven sons of gentlemen, and three sons of tradesmen. The day's work begins at 5.30 a.m. in winter, and is over at 8 p.m. Seven hours are devoted to practical work, five to study, the remainder being allowed for meals and recreation. In summer the students rise at 4.30 a.m.; otherwise, with the exception of an extra hour and a half for recreation, the studies are carried on as in winter.

THE additions to the Zoological Society's Gardens during the past week include two Australian Thicknees (*Œdicnemus grallarius*), an Eyton's Tree Duck (*Dendrocygna eytoni*) from Australia, two Lineated Parrakeets (*Bolborhynchus lineolatus*) from Mexico), two Senegal Touracous (*Corythaix persa*) from West Africa, purchased; two Elliot's Pheasants (*Phasianus ellioti* ♂ ♀) from China, deposited; a Hog Deer (*Cervus porcinus* ♀), two Mule Deer (*Cariacus macrotis* ♀ ♀), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

STONYHURST COLLEGE OBSERVATORY.—The results of the observations made during the year 1888 at this Observatory have recently been published in the ususal form. The bulk of the volume is occupied with the routine magnetic and meteorological observations, and an appendix gives the meteorological results for St. Ignatius College, Malta. The weather in 1888 was less favourable for the daily delineation of the solar surface than in 1887, but 223 full-sized drawings were secured. The daily areas of sun-spots derived from these show very strikingly, especially as given in graphical form, the nearness of our approach to minimum. The chromosphere was completely examined on eighty-four days, and partly on three other dates. The most important event of the year in connection with the Observatory has been the installation of a large grating-spectroscope for the especial purpose of photographing the solar spectrum, and the spectra of sun-spots in particular—a work which, in the present state of solar physics, greatly needed to be undertaken, and carried out with persevering regularity. The grating is a flat one, by Rowland, of 14,438 lines to the inch, and 3½ inches in length. It is to be used in connection with a heliostat and a 5½-inch object-glass by Alvan Clark. The preliminary experiments promise well for its efficiency, and the Director of the Observatory is to be greatly congratulated on so valuable an addition to his equipment.

The Rev. E. Colin, S.J., who spent the last year at Stonyhurst Observatory, has just been appointed Director of the French Government Observatory at Antananarivo.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JUNE* 16–22.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on June 16

Sun rises, 3h. 44m.; souths, 12h. 0m. 26·5s.; daily increase of southing, 12·8s.; sets, 20h. 17m.: right asc. on meridian, 5h. 40·2m.; decl. 23° 22′ N. Sidereal Time at Sunset, 13h. 58m.

Moon (at Last Quarter on June 20, 8h.) rises, 22h. 31m.*; souths, 2h. 35m.; sets, 6h. 44m.: right asc. on meridian, 20h. 13·2m.; decl. 21° 39′ S.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	4 25	12 20	20 15	5 59·8	20 14 N.
Venus ...	1 55	9 4	16 13	2 43·7	12 45 N.
Mars ...	3 41	12 2	20 23	5 42·1	24 4 N.
Jupiter ...	20 47*	0 42	4 37	8 19·6	23 11 S.
Saturn ...	8 5	15 38	23 11	9 18·1	16 55 N.
Uranus...	13 55	19 26	0 57*	13 7·0	6 27 S.
Neptune..	2 37	10 25	18 13	4 4·7	19 11 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

June.	h.	
18	2	Mars in conjunction with the Sun.
19	11	Mercury in inferior conjunction with the Sun.
21	6	Sun at greatest declination north; longest day in northern latitudes.

Variable Stars.

Star.	R.A.	Decl.			
	h. m.	° ′		h. m.	
U Cephei	0 52·5	81 17 N.	June 19,	22 47	*m*
V Boötis	14 25·3	39 21 N.	,, 16,		*m*
δ Libræ	14 55·1	8 5 S.	,, 17,	21 15	*m*
V Ophiuchi	16 20·6	12 10 S.	,, 16,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 17,	0 53	*m*
		and at intervals of		20 8	
X Sagittarii	17 40·6	27 47 S.	June 16,	22 0	*M*
			,, 21,	1 0	*m*
W Sagittarii	17 57·9	29 35 S.	,, 19,	0 0	*m*
Y Sagittarii	18 14·9	18 55 S.	,, 18,	1 0	*m*
T Serpentis	18 23·4	6 14 N.	,, 22,		*M*
R Scuti	18 41·6	5 50 S.	,, 18,		*m*
η Aquilæ	19 46·8	0 43 N.	,, 21,	2 0	*m*
T Vulpeculæ	20 46·8	27 50 N.	,, 20,	22 0	*m*
			,, 22,	0 0	*M*
δ Cephei	22 25·1	57 51 N.	,, 17,	2 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers

	R.A.	Decl.	
Near β Ursæ Majoris	170°	55° N.	
From Vulpeculæ	285	23 N.	Rather slow.
Near ε Cephei	335	57 N.	Swift.

GEOGRAPHICAL NOTES.

SIG. GIULIO BORELLI writes from Cairo to the May number of the Italian Geographical *Bollettino*, on the outflow of the River Omo, in connection with Count Teleki's recent discovery of Lake Rudolf (Samburu). Combining the data supplied by this explorer and his comrade, Lieutenant Hoenel, with his own observations further north, he finds that the Omo is a tributary neither of the White Nile nor of the Juba, as hitherto supposed, but almost certainly flows south to Lake Rudolf. But at its confluence with the Gojieb, south of Shoa, the Omo flows at an altitude of 1100 metres, about the same or very little more than that of Victoria Nyanza; and as beyond the confluence it has still a very long and rapid course, it follows that it cannot be a tributary of the great equatorial lake. Lake Rudolf stands at an elevation of about 550 metres, showing a fall of over 500 metres from the Gojieb confluence in a space of four degrees of latitude. Hence this basin, with its Omo feeder, can have no connection with the Nile, and, as asserted by its discoverers, is in fact a flooded depression without any outlet. Thus would appear to be solved one of the last hydrographical problems on the African continent.

AT the last meeting of the Russian Geographical Society it was definitely announced that the Society had decided to take part in the Geographical Congress which is to be held at Paris during the Exhibition. At the same meeting, Colonel Nadaroff communicated some interesting facts about the South Usuri region. It appears that the level of the great Lake Khangka, at the sources of the Usuri, has fallen to a considerable extent since the Russian occupation of the country thirty years ago. Even a hasty glance over the region of the Lower Amur and its tributaries, surrounded by numberless lakes, shows that the river-beds of the region belong to what Peschel described as "young rivers"—that is, rivers which have not yet completed the excavation of definite beds. It is natural, therefore, to suppose that the lakes which surround the Lower Amur must by and by be emptied into the channel of the great river, and thus in the meantime gradually diminish in size. M. Nadaroff's statement tends to confirm this view, and adds new facts in support of the theory of the rapid desiccation of Northern Asia.

AT the meeting of the Physical Section of the Russian Geographical Society on May 10, General Tillo made a communication about his remarkable hypsometrical map of European Russia, for which he has collected all available data obtained by levellings for the building of railways and along Russian rivers, as well as for the draining of marshes, together with data furnished by the trigonometrical survey of Russia and by individual explorers.

THE PRIORITY OF CHINESE INVENTIONS.

A WRITER in the *North China Herald* of Shanghai, referring to the Chinese claims to have originated many modern Western scientific inventions, says that Chinese patriotism has exhibited itself in an ardent desire to claim priority over Europeans in this respect. They are a very ingenious people, and, in past times having invented many valuable implements, it has always seemed to them a fair hypothesis that as every machine is an improvement on something that preceded it, the machinery and telescopes of the West may have originated at first in something Chinese. Yuen-yuen, a former Governor-General of Canton, in his "History of Astronomers," written at the beginning of this century, again prominently brought forward the idea that European mathematics came from China, and many subsequent writers have made the same claim. Not only is this the case in mathematics, but the Chinese say that our telescopes, steam-engines, firearms, and cannons are owing to them. Ever since China first saw steamers, fifty years ago, and since she came to know of the existence of European mathematics three hundred years ago, she has, from time to time, with more or less eagerness shown herself bent on claiming that the knowledge and skill shown in the West began in the first place with China. Mei-wen-ting, a great Chinese scholar, who died at an advanced age in the year 1722, after considering the whole question from the Chinese point of view, came to the conclusion that Europeans had got their mathematics and science from China. Amongst other reasons for this belief he states that in the "Chon-pi," a mathematical work of about B.C. 1100, although not expressly stated, the rotundity of the earth is implied. In the same book are to be found, he says, the properties of a right-angled triangle, as, for instance, that the square of the hypotenuse is equal to the sum of the squares of the other two sides. Since this is a fundamental problem, Mei-wen-ting claims that Western geometrical and trigonometrical knowledge is due to China. He accounts for the spread of Chinese astronomy to us by the scattering of the schools of astronomy in China, which, according to Szu-ma-chien, an historian who wrote a century before the Christian era, took place about B.C. 760. The fugitive astronomers, flying from the tyranny of the early Chow dynasty, diffused Chinese learning amongst the barbarians. Similarly in other matters the Chinese claim that the metaphysics of Indian Buddhism are due to the journey of Lao-tse to the West. The writer concludes his interesting discussion as follows:—"We need not trouble ourselves much respecting the Chinese claim to have originated Western science: they only claim to have started the preliminary ideas. As to the Chinese having always had enlightened views on many scientific and political subjects, we may frankly admit it. They speak 2200 years ago of concave and convex mirrors being able to magnify objects. Four thousand years ago they had instruments for observing the stars. In the year A.D. 1122 they made use of the magnet pointing to the south on board ship to guide the vessel on her course. With the proviso that they may have derived some of their early knowledge in these things and in others, such as the manufacture of fireworks, from foreign countries, these and many like facts we may allow. But we would be glad for them to study the history of Western inventions, and show a willingness to recognize the ingenuity, knowledge, and intellectual power of other nations wherever they are found. Let them also enter on a rivalry in inventions. Let them make new discoveries and advance in the arts in new ways such as may be of benefit in the world. The Western nations will not be slow to acknowledge any efficient aid they may give in science, politics, or the arts."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Nearly twenty courses of scientific and medical instruction for medical students will be carried on in the Long Vacation, including, besides chemical, botanical, anatomical, and physiological courses, Dr. Anningson and Mr. Robinson on the examination of water, air, and foods, chemically and microscopically, and Prof. Roy and Mr. Adami on pathology, morbid histology, and bacteriology.

The Museums and Lecture Rooms Syndicate have recommended the erection of the buildings required for human anatomy, together with the joint anatomical and physiological lecture-room, at a cost which will fall within the £10,000 reported to be available for the purpose.

The honorary degree of Doctor in Science has been conferred on Prof. Mendeleeff, of St. Petersburg; and the honorary M.A. on Baron A. von Hügel, Curator of the Museum of Archæology here.

The Senior Wrangler, Mr. G. T. Walker, and Messrs. Dyson and Gaul, bracketed Second Wranglers, are all members of Trinity College.

In the second part of the Mathematical Tripos, Messrs. Brunyate, of Trinity, and Orr, of St. John's, have been placed in the first division of Class I., in alphabetical order; and Messrs. Buchanan, of Peterhouse, and Sampson, of St. John's, in the second division of the first class.

The Moral Sciences Tripos seems in a state of rapid progress towards obliteration. This year one first class and one second class represent the men; and this is but natural, for the range of work is such as to task the energy and thoughts of a matured thinker.

SOCIETIES AND ACADEMIES.

LONDON.

Chemical Society, May 16.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—The magnetic rotation of nitrogen compounds, by Dr. W. H. Perkin, F.R.S. In previous communications the author has shown that in the magnetic field the plane of polarization of light is rotated to a greater extent in unsaturated than in saturated carbon compounds, and it is now shown that in the case of nitrogen compounds the magnetic rotation is in like manner correlated with changes in the valency of the nitrogen. From the discussion of his results generally the author concludes that in compounds of unsaturated triad nitrogen, the nitrogen has a greater influence than when it is present in the saturated condition, the difference in the values being about 0·5; this is only about half the difference usually observed on comparing the rotations of carbon compounds differing by two atoms of hydrogen. In the discussion which followed the reading of the paper, Dr. Gladstone, F.R.S., said that the general result of Dr. Perkin's work, establishing a difference in nitrogen according as it is present in the saturated or unsaturated condition, was in accordance with the conclusion which he had arrived at from the study of refractive power; the peculiarities brought out by the study of the magnetic behaviour, however, were chiefly indicated by peculiarities in dispersive power, being less obvious in the refraction equivalents.—The nature of solutions as elucidated by a study of their densities, electric conductivities, heat capacity, and heat of dissolution, by Mr. S. U. Pickering. The solutions examined were those of calcium chloride, calcium nitrate, and sulphuric acid, and the various hydrates which are proved to exist in solution are numerous and complex. The hydrates which calcium chloride forms contain 6, 7, 8, 10, 13, 18, 28, 86, and 1500 H_2O; calcium nitrate gives hydrates with 3, 3·5, 4·5, 5, 6, 10, 17, 51, 265, and 1810 H_2O; while with sulphuric acid hydrates are found containing $\frac{1}{6}$, $\frac{1}{3}$, $\frac{2}{3}$, 1, $\frac{3}{2}$, 2, 4, 5, 9, 13, 24, 52, 135, 510, 1430, and 4950 H_2O. The existence of these is, naturally, more doubtful in some cases than in others, and it is impossible to determine the exact molecular composition when more than about $10H_2O$ is present. In some cases the hydrates of sulphuric acid were established by six independent sets of results obtained from the study of four distinct properties. The excessively large amount of water present in the highest hydrate is a matter of especial interest, and the existence of such compounds explains the influence which mere traces of one substance may have on another substance (*e.g.* impurities in metals). The final conclusion which the author deduces from his work is the absolute rejection of any theory of dissolution other than the hydrate theory.—The expansion of water and other liquids, by the same. The author gives some determinations of the density of water at different temperatures, which indicate sudden changes in the expansion at about 10° and 18°. On examining the results obtained by Pierre, Kopp, Rosetti, Matthiessen, Solly, Despretz, and Hagen, he obtained further evidence of these changes, as well as of another change at 50°–60°. Pierre's results also show marked changes at 0° and 2°·5. Pierre's results with eleven organic liquids were also examined, and in most of them there appeared to be sudden changes of density at certain temperatures, which temperatures were different for different liquids. Nearly all of these results show that the densities of liquids when plotted against temperature form a series of parabolic curves of the second order, not meeting tangentially, and differentiating, therefore, into a series of straight lines which do not meet at the points where the breaks occur.—The formation of phenylindoles by isomeric change, by Dr. W. H. Ince. It is known that the phenylindole $C_6H_4\left\langle\begin{matrix}CPh\\NH\end{matrix}\right\rangle CH$, when heated with zinc chloride at 170°, is converted into the isomeride $C_6H_6\left\langle\begin{matrix}CH\\NH\end{matrix}\right\rangle CPh$ (Fischer and Schmitt, *Ber. der deut. chem. Gesellsch.*, 1887, 1071, 1811). The author finds that the corresponding naphthindole, $C_{10}H_6\left\langle\begin{matrix}CPh\\NH\end{matrix}\right\rangle CH$, and methylphenylindole, $C_6H_4\left\langle\begin{matrix}CPh\\NMe\end{matrix}\right\rangle CH$, undergo a like change under similar conditions, although action takes place neither so easily nor so completely as in the simpler case.—An improved Soxhlet extractor, and vacuum distilling apparatus, by Dr. I. Lewkowitsch.

Institution of Civil Engineers, May 28.—Annual General Meeting.—Sir George B. Bruce, President, in the chair.—After the reading and adoption of the Report, hearty votes of thanks were passed to the President, to the Vice-Presidents, and other Members of the Council, to the Auditors, to the Secretaries and Staff, and to the Scrutineers.—The ballot for the Council resulted in the election of Sir John Coode, K.C.M.G., as President; of Mr. G. Berkley, Mr. H. Hayter, Mr. A. Giles, M.P., and Sir Robert Rawlinson, K.C.B., as Vice-Presidents; and of Mr. W. Anderson, Mr. B. Baker, Mr. J. W. Barry, Mr. E. A. Cowper, Sir James N. Douglass, F.R.S., Sir Douglas Fox, Mr. J. C. Hawkshaw, Mr. C. Hawksley, Sir Bradford Leslie, K.C.I.E., Mr. G. F. Lyster, Mr. J. Mansergh, Mr. W. H. Preece, F.R.S., Sir E. J. Reed, K.C.B., F.R.S., M.P., Mr. W. Shelford, and Mr. F. W. Webb, as other Members of the Council.—The session was then adjourned until the second Tuesday in November, at 8 p.m.—The Council have awarded the following premiums in respect of the original communications submitted during the session 1888–89:—For papers read and discussed at the ordinary meetings: a Telford Medal and a Telford Premium to Gisbert Kapp, for his paper on alternate-current machinery; a Watt Medal and a Telford Premium to William Henry Greenwood, for his paper on the treatment of steel by hydraulic pressure, and the plant employed for the purpose; a George Stephenson Medal and a Telford Premium to Edgar Worthington, for his paper on the compound principle applied to locomotives; a Watt Medal and a Telford Premium to Charles Edward Emery, for his paper on the district distribution of steam in the United States; a Telford Premium to John Audley Frederick Aspinall, for his paper on the friction of locomotive slide-valves; a Telford Premium to John Oliver Arnold, for his paper on the influence of chemical composition on the strength of Bessemer steel tires. For papers printed in the Proceedings without being discussed: a Watt Medal and a

Telford Premium to Robert Runeberg, for his description of steamers for winter navigation and ice-breaking; a Telford Premium to Bryan Donkin, Jun., for his account of experiments with gas-flame jackets; a Telford Premium to Prof. Victor Auguste Ernest Dwelshauvers Dery, for his reduction of experiments on the effect of superheating, steam-jacketing, and gas-flame jackets on cylinder-condensation; a Telford Premium to Robert Henry Smith, for his paper on stress diagrams of solid structures; a Telford Premium to Leveson Francis Vernon-Harcourt, for his paper on Alpine engineering; a Telford Premium to George Lopes, for his account of the reparation of Betchworth Tunnel, Dorking, on the London, Brighton, and South Coast Railway; a Telford Premium to Neil Kennedy, for his paper on the tacheometer and its uses. For papers read at the supplemental meetings of students: a Miller Scholarship to Edward Carstensen de Segundo, for his account of experiments on the strain in the outer layers of cast-iron and steel beams; a Miller Prize to Henry Byrom Ransom, for his paper on the cyclical velocity-variations of steam and other engines; a Miller Prize to William Wade Fitzherbert Pullen, for his account of water-softening and filtering apparatus, for locomotive purposes, at the Taff Vale Railway Company's Penarth Dock Station, near Cardiff; a Miller Prize to James Denis Twinberrow, for his paper on flexible wheel-bases for railway rolling-stock; a Miller Prize to Samuel Joyce, Jun., for his paper on electrical measuring-instruments, their properties and calibration; a Miller Prize to Richard John Durley, for his paper on moulding and casting cylinders for marine engines; a Miller Prize to Julian James King-Salter, for his description of the 26-knot Spanish torpedo-boat *Ariéte;* Miller Prizes to Charles Henry Gale and Vernon Warburton Delves-Broughton, for their joint paper on photography for engineers.

Geological Society, May 22.—Mr. W. T. Blanford, F.R.S., President, in the chair.—The following communications were read:—Note on the hornblende schists and banded crystalline rocks of the Lizard, by Major-General C. A. McMahon. The reading of this paper was followed by a discussion, in which the President, Dr. Geikie, Mr. Teall, Prof. Bonney, Mr. Rutley, and Dr. Hicks took part.—The Upper Jurassic clays of Lincolnshire, by Mr. Thomas Roberts. In Lincolnshire it has generally been considered that the Oxford and Kimeridge clays come in direct sequence, and that the Corallian group of rocks is not represented. The author, however, endeavoured to show that there is between the Oxford and Kimeridge a zone of clay which is of Corallian age. Six palæontological zones were recognized in the Oxford clay. The clays which come between the Oxford and Upper Kimeridge the author divided into the following zones: (1) black selenitiferous clays; (2) dark clays crowded with *Ostrea deltoidea;* (3) clays with *Ammonites alternans;* and (4) clays in which this fossil is absent. The black selenitiferous clays (1) are regarded as Corallian, because: (*a*) they come between the Oxford clay and the basement bed of the Kimeridge; (*b*) out of the twenty-three species of fossils collected from this zone, twenty-two are Corallian; (*c*) *Ostrea deltoidea* and *Gryphæa dilatata* occur together in these clays, and also in the Corallian, but in no other formation. The zones (2), (3), and (4) are of Lower Kimeridge clay age. The lowest zone, (2), is very persistent in character, and is met with in Yorkshire, Cambridgeshire, Oxfordshire, and the south of England. The remaining zones, (3) and (4), are local in their development. Some remarks on this paper were offered by Prof. Blake and Mr. Hudleston.—Origin of movements in the earth's crust, by Mr. James R. Kilroe. Communicated by Mr. A. B. Wynne.

Zoological Society, May 21.—Prof. Flower, F.R.S., President, in the chair.—Mr. Sclater exhibited and made remarks on a mummied Falcon from Egypt; and some photographs of groups of Sea-birds and Seals taken on the shores of Antipodes Island, Antarctic Ocean.—Mr. Sclater also called attention to a specimen of Leaf-insect, living in the Society's Insect House, which had been received from the Seychelles, and presented by Lord Walsingham. It was not quite fully developed, but was believed to be referable to *Phyllium gelonus*, Gray.—Mr. Martin Jacoby read a list of the species of Coleoptera of the families Crioceridæ, Chrysomelidæ, and Galerucidæ, of which specimens had been collected in Venezuela by M. Simon, and gave descriptions of the new species.—A communication was read from Mr. A. G. Butler containing the description of a new extinct genus of Moths belonging to the Geometrid family Euschemidæ, based on a fossil specimen obtained from the Eocene Freshwater Limestone of Gurnet Bay, Isle of Wight. This insect was named *Lithopsyche antiqua*.—Mr. W. F. Kirby read a paper containing descriptions of new genera and species of Dragonflies in the collection of the British Museum, chiefly from Africa.—Dr. Hans Gadow read a paper on the taxonomic value of the intestinal convolutions in birds. After pointing out the different forms assumed by the intestinal convolutions in this class of animals, and suggesting a nomenclature for them, the author proceeded to give the outlines of a classification of birds based solely on this part of their structure, and to show the differences and resemblances of the various groups.

Edinburgh.

Royal Society, June 3.—Sheriff Forbes Irvine, Vice-President, in the chair.—Some photographs of mirage were exhibited.—Prof. T. R. Frazer communicated the remainder of his paper on the natural history, chemistry, and pharmacology, of *Strophanthus hispidus*.—Prof. Tait read a note on the compressibility of mercury.—Dr. E. Sang gave a notice of fundamental tables in trigonometry and astronomy arranged according to the decimal division of the quadrant.—Prof. Tait communicated a note on the inscription, in a sphere, of a closed polygon, each of whose sides shall pass through a given point, and he also discussed the problem of the non-oscillating pendulum.—A paper, by Sir W. Thomson, on the Bravais' uniform distribution of points, was submitted.

Paris.

Academy of Sciences, June 3.—M. Des Cloizeaux, President, in the chair.—Heat of combustion of carbon under its various forms of diamond, graphite, and amorphous carbon, by MM. Berthelot and Petit. By means of the new methods based on the employment of the calorimetric bomb, the authors have determined the molecular heat of combustion of amorphous carbon at 97·65 calories; of crystallized graphite at 94·81; of the diamond at 94·31; and of bort (uncleavable diamond) 94·34. The old values, hitherto accepted, must consequently be considerably increased, and this again involves an increase of the heats of formation for all organic compounds, from their elements upwards, so far as they have yet been calculated.—Note on the spectrum of Uranus, by Mr. J. Norman Lockyer.—On the surface-currents of the North Atlantic, by Prince Albert of Monaco. Of the 1675 floats cast into the sea during the recent explorations of the *Hirondelle*, as many as 146 have already been recovered at various points of the seaboard, apparently demonstrating a circular movement of the surface-waters round a point situated somewhere to the south-west of the Azores. The outer edge of this current sets east-north-east to the neighbourhood of the English Channel, where it is deflected southwards along the coasts of Europe and Africa to the Canaries, thence trending south east to the equatorial current, thus completing the circuit by merging in the Gulf Stream.—On Prof. Charles Sumner Tainter's graphophone, by M. Georges R. Ostheimer. The essential feature of this instrument, which solves the problem of the storage of sound, is the employment of wax, or a pasteboard cylinder coated with wax. The process, devised by Prof. Tainter after the original phonograph had been discarded by Mr. Edison as of no immediate practical utility, has since been so highly approved of by the American inventor that he has adopted it for what he now calls his "improved phonograph."—Observations of the new planet discovered on May 29 at the Observatory of Nice, by M. Charlois. The observations are for the period May 29-31, when the planet appeared to be of the twelfth magnitude.—On the stability of the solar system, by M. D. Eginitis. The authors here study the nature of the slight perturbations usually neglected in planetary theories, and endeavour to determine their more important general analytical forms. The results are given for the earth and Saturn, showing that the long axes of their orbits are subject to extremely slight secular perturbations of the third order. These irregularities are periodical, the periods being excessively long, but of such a nature as to imply that both Saturn and the earth are at present approaching the sun.—Apparatus for determining melting-points under ordinary conditions and variable pressures, by M. B. C. Damien. The apparatus here described will be found useful in determining the melting-points of various mixtures of spermaceti and ether, of gum-lac and alcohol, and in general of solidified solutions of various solids.—The electric conductivity of saline solutions, applied to the problems of chemical mechanics, by M. P.

Chroustchoff. In continuation of his previous paper on this subject the author here gives in tabular form the measurements of the conductivity of neutral saline mixtures capable of double decomposition. In a supplementary paper, MM. Chroustchoff and V. Pachkoff deal with the electric conductivity of saline solutions containing mixtures of neutral salts. The chief object of this research is to confirm by experiment the assumption that a partial formation of double salts in solutions is a general phenomenon. — On some substances derived by polymerization from ethyl cyanide, by MM. M. Hanriot and L. Bouveault. The preparation and properties are described of two bodies of which the formulæ are respectively $C_2H_5 . CO . C(CH_3)_2CN$ and $C_2H_5 . CO . C(C_2H_5)(CH_3)CN$, the former obtained by the action of methyl iodide, the latter by that of ethyl iodide.—On some rocks of the Maures district, by M. A. Le Verrier. Of the old eruptive rocks here described the most interesting is a lherzolite consisting of olivine and hypersthene (labrador schiller spar), the first associated with serpentine, the second with talc.—On the toxic property of meteoric waters, by M. Domingos Freire. An epidemic presenting some hitherto unknown symptoms having broken out at Rio de Janeiro last March, the author, with a view to determining its origin, made some experiments on the character of the aqueous vapour suspended in the atmosphere. The result of these experiments was a strong suspicion, if not certainty, that the disorder was due to a toxic principle diffused in the atmosphere, and belonging perhaps to the cyanic series (hydrocyanic acid ?).—Papers were contributed by M. G. André, on some ammonio-chlorides of mercury; by M. E. Péchard, on the combinations of metatungstic acid with the alkaline bases and the resulting thermic phenomena; by M. Léon Bourgeois, on the preparation of the crystallized orthosilicates of cobalt and nickel; by M. Trouessart, on the marine Acarians of the French seaboard; by M. Flammarion, on the earthquake of May 30; and by M. Th. Moureaux, on the possible connection of magnetic disturbances with the same earthquake.

BERLIN.

Physical Society, May 24.—Prof. du Bois Reymond, President, in the chair.—Prof. Börnstein exhibited a photograph which he had taken during the recent heavy thunder-storms. Two flashes could scarcely be distinguished on the photograph owing to the marked occurrence of sheet lightning; they appeared as simply very sinuous lines without any zig-zags.—Dr. Pringsheim had carried out a series of researches with the phonautograph in order to determine by physical methods upon what the French accent is dependent, whether it is due to the duration, pitch, or intensity of the tones. Several Frenchmen spoke single words and short sentences slowly into the funnel of the instrument so as to impinge upon a membrane, made of the thinnest india-rubber, whose vibrations were recorded on a smoked rotating drum by means of a fibre of glass. The somewhat troublesome analysis of the minute curves brought to light very characteristic waves for the consonants, but these differed considerably according as they were spoken at the beginning or end of a word. The vowels showed a considerable difference from the consonants chiefly in respect of their pitch. The speaker exhibited and explained a number of the curves; but further researches are necessary before any general conclusions can be arrived at, or the question as to the real nature of "accent" can be decided.—Dr. Dieterici gave an account of his researches on the determination of the specific volume of saturated aqueous vapour at 0° C. On account of the difficulties which presented themselves in connection with the measurements necessary in the methods of research hitherto employed, he had devised a new method. He measured the amount of water which must be converted into vapour at 0° C. in order to completely fill a known space with saturated vapour, by means of the heat which becomes latent during its evaporation. The vessel containing the water was immersed in an ice-calorimeter, and was connected with a large space which could be rendered both vacuous and dry. The water, or dilute saline-solution which behaves like water, was then allowed to evaporate until the space was filled with saturated vapour; the amount of heat requisite to produce the observed evaporation was determined from the amount of mercury which was expelled from the calorimeter, and this then gave the amount of water evaporated. From among the experimental details, which the speaker described in full, the only points which may here be mentioned are that a small residual quantity of air in the vacuum has no effect on the total amount of water which evaporates, but only slows the rate of evaporation to a slight extent; on the other hand, the pellicle of water which is condensed on the inner surface of the vacuous space was found to exert a quantitative influence on the evaporation, and necessitated special modifications of the methods of experiment for its exclusion. As one outcome of the experiments may be mentioned that Gay Lussac's law holds good almost up to the temperature of saturation, and that the mass of water which must be evaporated in order to saturate a space of 1 litre capacity at 0° C. is 4·886 mgr.; hence the specific volume of aqueous vapour saturated at 0° C. is 204·7 litres, and its pressure is 4·62 mm. The speaker had deduced a considerable number of other important constants from the results of his experiments; and he further intends to determine the above for other fluids and at other temperatures in a subsequent research.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

An Essay on Asphyxia: G. Johnson (Churchill).—The Working and Management of an English Railway: G. Findlay (Whittaker).—Scientific Memoirs by Medical Officers of the Army of India, Part 4, 1889: edited by Sir B. Simpson (Calcutta).—Método de los Cuadrados Minimos: Libro de Texto por M. Merriman; traducido del Inglés por V. Balbin (Buenos Aires, Biedma).—Blackie's Modern Cyclopedia, vol. ii. (Blackie).—Life Lore, vol. i. (Mawer).—Kant's Critical Philosophy, a new and completed edition, vol. i., the Kritik of Pure Reason Explained and Defended: J. P. Mahaffy and J. H. Bernard (Macmillan).—An Elementary Treatise on Heat: H. G. Madan (Rivingtons).—Transactions of the Linnean Society of London. vol. v., Part 3, the Zoology of the Afghan Delimitation Commission: J. E. T. Aitchison (Longmans).—A Grammar of the Kwagiutl Language: Rev. A. J. Hall (Montreal, Dawson).—Rapporteur Esthétique: M. C. Henry (Paris, Seguin).—Cercle Chromatique: M. C. Henry (Paris, Verdin).—The Mineral Wealth of British Columbia: G. M. Dawson (Montreal, Dawson).

CONTENTS.

THURSDAY, JUNE 20, 1889.

EVOLUTION ETHICS.

Moral Order and Progress: an Analysis of Ethical Conceptions. By S. Alexander. "English and Foreign Philosophical Library." (London: Trübner, 1889.)

"IT will be found that moral ideals move by a process which, allowing for differences, repeats the law by which natural species develop. . . . The growth of a new ideal is analogous to the growth of a new species in the organic world. According to the generally accepted view, a new species is produced through giving rise to variations which struggle with one another and with the parent species. . . . The good ideal has been created by a struggle of ideals in which it has predominated. Evil is simply that which has been rejected and defeated in the struggle with the good." These sentences contain the key-note of Mr. Alexander's able and valuable work--a work which will be read with interest by students of ethics of whatever school. Based upon a dissertation, for which Mr. Alexander obtained the Green Moral Philosophy Prize at Oxford in 1887, written by one who has carefully studied and grasped the principles set forth by Mr. Herbert Spencer and Mr. Leslie Stephen, this work is in some sense the offspring of the fertile union of the "Prolegomena" and the "Science of Ethics." Or, as he himself expresses it, coming to the ideas borrowed from biology and the theory of evolution, which are prevalent in modern ethics, with a training derived from Aristotle and Hegel, Mr. Alexander has found "not antagonism, but, on the whole, fulfilment."

Morality being a matter of conduct and the outcome of character, the first book of the three into which Mr. Alexander's work is divided deals with conduct and character, which he regards as the same thing facing different ways. Think of a man's conduct in relation to the mental conditions from which it proceeds, and you think of his character: think of his character as it produces results beyond these sentiments themselves, and you have conduct. Following in the footsteps of Prof. Max Müller, who identifies language with thought, Mr. Alexander thus identifies conduct with character. As language is the expression of thought, so is conduct the expression of character. But just as thought is not co-extensive with the psychological field, so is conduct not co-extensive with the field of action. Conduct is willed action: it implies volition. And Mr. Alexander goes so far as to deny to the brutes any share in conduct, any participation with us in volition. Character, too, as identical with conduct, or merely another aspect thereof, implies volition. Non-volitional activities are not the outcome of character; they merely arise out of the disposition or temperament of the agent. Animals have dispositions, but no character.

What, then, is the nature of that volition which distinguishes character and makes morality possible? It is this: that "when a man wills he does not merely perform an act which issues in a certain end, but has before him the idea of the end, or is conscious of his object, or, in homely language, knows what he is doing, though he need not reflect on what he is doing." The presence of the idea then, as such, distinguishes volition (human) from mere impulse (animal). But the presence of the idea also distinguishes desire: whence desire would also seem to be restricted to man. Desire consists in the feeling of tension, which may be described as a sense of disparity between the ideal object and the actual state of the agent. The act of volition is the passage from the actual state to the ideal state: it is the conscious realization of the ideal.

Moral action, then, in Mr. Alexander's system being willed action, we naturally turn to see what his position is with regard to the free-will controversy, and we find him occupying the standpoint of determinism. It would have been well, perhaps, to state this earlier than in the last chapter but one of the work. But, though there is no index, his table of contents contains a full and clear conspectus of the argument, and a little trouble enables the reader to turn to this or other points on which he may desire information in the course of his perusal. The idea of a free will in the sense of an undetermined will is, Mr. Alexander believes, "a sheer delusion." Though invented to save responsibility, free will, he says, renders it inexplicable. A will independent of motives could never be responsible because it would not be called to account. Mr. Alexander connects responsibility and punishment. When we call a bad man responsible, we mean that the good man holds him to be justly punished. "His responsibility lies in a feeling not on his own part, but on the part of the good, just as the badness of his action consists in the good man's disapprobation."

We must leave the upholders of the doctrine of free will to pick serious holes in Mr. Alexander's argument. But accepting with him the determinist position, we think there are certain points which he might have made clearer. He says, in effect, that a man is responsible for such acts as are the outcome of his character (willed acts), but not for such as are the outcome of his disposition (impulsive acts). For these but not for those he is justly punishable. It is idle, he says, to praise a feeling [or action] which cannot be commanded: what is praised is its indulgence or its cultivation. But if both are inexorably determined, why is the one more praiseworthy than the other? Why is it just to punish one set of actions and not the other? We punish the dog for certain of his actions, though in Mr. Alexander's view he cannot be responsible for them. Do we not often punish, and that wisely, men for similar acts for which Mr. Alexander would not hold them responsible? The distinction between willed acts and impulsive acts, as defined by Mr. Alexander, is a valid distinction in psychology. But does not determinism break down this distinction (or at least make it somewhat arbitrary) when we come to responsibility? Does Mr. Alexander mean that it is *practically convenient* to hold men responsible for the (determined) acts of will: or does he consider the psychological distinction a justification for the moral distinction? Undoubtedly, as it seems to us, the latter; for he contends that the sphere of morality is the sphere of willed action. The evil that a man does as the impulsive outcome of his disposition he regards as a subject for pity, but not for moral aversion. His psychological basis is clear; but we think he might have more explicitly reconciled it with his determinism.

We must now pass on to consider that part of the work which deals with the struggle of ideals. Moral order Mr. Alexander regards as an equilibrium. This is seen both in the individual and in society. The good man is described as an equilibrated order of conduct, or an equilibrium of moral sentiments. Good and bad acts and conduct are distinguished by their adjustment or failure of adjustment to the social order. Good conduct falls within the order; bad conduct fails to adjust itself and is condemned. The equilibrium is not a state of rest, but a mobile equilibrium in which all the parts are shifting. The conception of a man's character is represented under the name of an *ideal*—a plan of conduct or way of life upon which he acts. A bad man's way of life is his ideal as much as the good man's, and every one of his acts implies such an ideal. Moral progress results from a conflict of ideals and the elimination of those which are bad. But not only are there, in any given society, a great number of interdependent individuals, each with his moral ideal, but the society itself may be regarded as an individual (the social organism) having relations to other social individuals of the same order. Hence arises the conception of a social ideal.

With regard to this social ideal, what it is, and wherein it lies, Mr. Alexander is not quite explicit—or perhaps the fault is in ourselves; for we have always found the social organism a difficult conception. It is clear that the social ideal cannot in any sense be the mean of the individual ideals of the constituent units of the society. It is presumably not the ideal of the average man. It must be, we take it, the moral ideal of the perfectly "equilibrated" individual —of the man in completely harmonious adjustment with his social surroundings. Such a representative man may not exist in the flesh; but he represents the ideal standard of the social morality of his time. After-times may show that there existed contemporaneously individuals with far loftier ideals than the social standard. But these were not perfectly equilibrated with their social surroundings, and not improbably paid the penalty for their want of equilibrium.

The social ideal is thus the type-form of a species of which the various ideals, as they exist in the minds of good men, are the different individuals. "But," says Mr. Alexander, "the type in the case of man is, owing to his social character, itself an organism of which the individual is an organ. Hence, if we are to use the analogy at all, we must compare the relation of a species to its individuals with that between the social ideal and the individual ideals." A little later on we read that "an ideal is nothing but a person in so far as he acts the ideal." We fail satisfactorily to correlate the idea of the type as organism of which the individual is an organ, with that of he social ideal as species of which the personal ideals are individuals.

Mr. Alexander next proceeds to show: (1) that the social ideal varies; (2) that there is a struggle between the varieties; (3) that the prevalence of good, and successively better ideals constitutes moral progress. "All good men, so far as good, represent ideals which are the individual members of one variety represented by the good ideal: their various degrees of perfection correspond to more or less strong, or swift, or big members of the animal species. All bad men, so far as bad, act upon ideals which form other varieties. There is the variety of thieves, of murderers, and the like. The distinction of good and bad corresponds to the domination of one variety, that of the good, which has come to prevail according to the process described in virtue of its being a social equilibrium."

The differences between the struggle of ideals and the struggle of animals under nature are not slurred over by Mr. Alexander. "In morality," he says, "the struggle is between *ideals*, and persons are concerned only as the bearers of these ideals. Ideals of conduct exist in minds (wills), not in bodies. Hence two important differences. The animal variety predominates by two concurrent methods: it multiplies its offspring, and it exterminates other animals, and these two things are practically the same, for other animals die out before the spread of the more successful. But in man the predominance of the good does not always require, and except in extreme cases never requires, the extinction of the opposing person, but only the extinction of his ideal, or its retirement from his mind or will in favour of the good ideal. In the next place, whereas animals multiply by propagation of new individuals, the moral ideal acquires strength by teaching and example, and it acquires adherents not only among the new generation but among the old. Hence, while if an animal variety were composed of only a few individuals it would perish, the reformer's cause may win though he individually is destroyed. His ideal lives on in the minds of those whom he has influenced, and his influence may grow greater with his death."

Enough has now been said—and as much as our space will permit—to indicate the scope of Mr. Alexander's conception of the nature and methods of moral progress. How he works in such biological ideas as degeneration and mimicry—the bad man simulating the external actions of the good—must be ascertained from the work itself.

And what shall we say of this conception? Fully admitting the value of Mr. Alexander's independent treatment of the subject, it still seems to us that the separation of the moral ideals from the men and women whose product they are is unsatisfactory. All that Mr. Alexander contends for could be as well, nay better, explained as the result of the interaction of moral and immoral human beings under the conditions of social co-operation and the varied play of social life. For the purposes of ethical science they may be divided, according to their ideals of conduct, into moral varieties. And in the course of their individual moral development they may pass through several varietal states. The struggle among men and women differs very considerably from the struggle among animals, from the fact that man is, in virtue of his high mental development, more plastic, that he is to so large an extent a conscious agent in his own evolution, and that his environment is a social environment of similar conscious agents. It is questionable whether the conception of a social organism and a moral organism helps us much. In any case it has to be used with extreme care and with many reservations. And if we can reach as good results with the more prosaic and less imaginative conception of a co-operative society of human individuals, we shall be wiser, and shall act more in accordance with the spirit of science, to adhere to that conception which sticks closest to the facts of organic life. We doubt whether Mr. Alexander's work would have suffered anything by dealing with men and women possessed of moral ideals, instead of ideals floated off in imagination from their bearers; and we think it would have gained considerably in practical directness, and points of application to the facts of social life.

We cannot take leave of Mr. Alexander's work without again expressing our warm appreciation of its earnestness, its ability, and its orderly method. It is a valuable contribution to ethical literature. C. LL. M.

THE ZOOLOGICAL RESULTS OF THE "CHALLENGER" EXPEDITION.

Report on the Scientific Results of the Voyage of H.M.S. "Challenger" during the Years 1873–76, *under the command of Captain George S. Nares, R.N., F.R.S., and the late Captain Frank T. Thomson, R.N.* Prepared under the superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S., &c., Director of the Civilian Staff on board, and now of John Murray, LL.D., Ph.D., &c., one of the Naturalists of the Expedition. Zoology—Vol. XXX. Published by Order of Her Majesty's Government. (London: Printed for Her Majesty's Stationery Office, and sold by Eyre and Spottiswoode, 1889.)

VOLUME XXX. of the zoological series of the *Challenger* Reports contains an account of the Asteroidea by W. Percy Sladen, and is without doubt one of the most important of the whole series.

The Report contains a description not only of the species collected during the cruise of the *Challenger*, but of those collected during the cruises of the *Lightning*, *Porcupine*, *Knight Errant*, and *Triton*. In the *Challenger* collection there were 84 genera, 5 subgenera, 268 species, and 13 varieties. 184 species and 12 varieties are described as new, and several new genera are established; the new species and varieties found during the other expeditions bring up the total of new species to 196, and new varieties to 15.

In the latest summary of the Asteroidea, published by Prof. Perrier in 1878, he enumerates 52 genera, which Mr. Sladen reduces to 49, and of these, representatives of no less than 38 were obtained by the *Challenger;* thus indicating in a striking manner that the collection affords a fair representation of the general character of the Asteroid fauna of the globe.

The large number of deep-sea forms, belonging to previously unknown types, as well as the very peculiar features distinguishing most of these, demanded a quite new classification; and Mr. Sladen has framed one in accordance with morphological characters, which is certainly far in advance of any that have hitherto been made. The usefulness of this Report has been greatly increased, without its bulk being materially added to, by a list given under each genus of all its authentic species, and their geographical distribution.

At the end of the Report there is added a synoptic list of all the known species of recent Asteroidea, with particulars of their geographical distribution, also their distribution in depth and their synonymy. This most carefully compiled list will be of the greatest value to all interested in the study of this group. 137 genera and 810 species are therein enumerated.

The introduction opens with a history of the classification of the Asteroidea, the earliest attempt at which was made by Linck in 1733. This, which was a purely artificial one, was not improved on by Linnæus or Lamarck. In 1840, Müller and Troschel published their well-known classification, chiefly based on the presence or absence of an anal orifice, and on the arrangement of the ambulacral tube-feet; and this formed the basis of all systematic arrangements of the group until 1875, when Prof. Perrier insisted on the importance of the pedicellariæ from a classificatory point of view, in addition to the disposition of the ambulacral feet. A couple of years later Viguier published his elaborate researches on the skeleton of the Asteroidea, and on these also proposed an amended arrangement of the group. In 1854, Prof. Perrier again discussed the question, examining it from Viguier's standpoint, but concluded to retain the pedicellariæ as the basis of his system of classification, which indeed he but slightly modified.

Mr. Sladen briefly gives his reasons for dissenting from the views of Perrier; and passing in review the various morphological features or fundamental points of structure which are common to the whole class, selects the following: (1) the adaptation of the organism to subserve the functions of respiration and excretion; (2) the character of the ambulacral skeleton; (3) the character of the ambital skeleton.

For the first of these he selects the organs called "papulæ" by Stimpson, which penetrate the body-wall in the form of delicate transparent membranous cæca, permitting an exchange of fresh fluid from without by osmosis, thereby introducing oxygen; these "papulæ" may be distributed over the whole body, or may be confined to a limited area, and thence the division into the Stenopneusia, and the Adetopneusia.

The ambulacral skeleton exhibits two modes of growth; in the one the production of parts is accelerated in relation to the growth of the starfish, in the other the production of parts is retarded, or proceeds *pari passu* with the general development of the skeleton. The ambital skeleton is formed by the marginal plates and their supplementaries when present; these the author considers one of the most important systems of plates in the body, as determining form and superficial character.

The introduction concludes with a summary of the classification as far as the genera, and a synopsis of the orders and families is also given.

The description of the species calls for no remark, unless the critical one in passing that according to the usual practice the date of the publication of this volume, not the date when the individual sheets contained therein were passed "for press," must be taken as those for the new families, genera, and species. No less than 109 species and varieties were found at depths from 500 to 2500 fathoms. The volume consists of 935 pages, and is accompanied by an atlas of 118 plates, which well merit our special praise. In most instances the figures of the abactinal and actinal aspects of each species is given on one plate, and then in the plate following we have the magnified details of the mouth-plates, the supradorsal membrane, the adambulacral plates, and other characteristic portions.

The publication of this Report cannot fail to give a fresh stimulus to the study of this hitherto rather neglected group of the Echinoderms, and the best thanks of every student of natural history are due to Mr. Sladen for the thorough and honest manner in which he has accomplished a troublesome and arduous task.

GREEK GEOMETRY FROM THALES TO EUCLID.

Greek Geometry from Thales to Euclid. By Dr. G. J. Allman, F.R.S. (Dublin: Hodges, 1889.)

THE subject-matter of this work has at different times been brought under the notice of the readers of NATURE, for it is very little more than a collected and corrected reproduction of papers which have at varying intervals appeared during the last eleven years in *Hermathena.* In all our previous notices, we believe, we strongly insisted upon the desirability of Dr. Allman's giving a permanent form to his labours, which should render his brilliant achievements the more readily accessible to mathematical and, we may say also, to general readers. Hitherto all the original investigation in this direction has been carried on by German, French, and Danish writers, for Mr. Gow's "Short History of Greek Mathematics," interesting though it is, is confessedly not founded upon independent research, nor does Mr. Heath's "Diophantus," concerned as it is with Greek algebra, form exception to our statement. In the historical domain of mathematics, Montucla held sway until quite recently, and even the latest French work, by M. Marie, the outcome of forty years' travail, holds fast by him, so that Heiberg (quoted by our author) writes: "The author [Marie] has been engaged with his book for forty years: one would have thought rather that the book was written forty years ago." Far different is the case with Dr. Allman: all along the line of his labours he has consulted the original Greek authorities, and fought every inch of the ground with such experts as Heiberg, Bretschneider, Cantor, Tannery, and several other writers we could name, many times adopting their results, but in nearly as many cases putting forward and convincingly maintaining views of his own. In evidence that the views we have all along held of the importance of this contribution to our knowledge of the early Greek geometers was not a singular one, we have now the confirmation of the favourable reception the papers in their original form met with from many competent authorities on the Continent and elsewhere, the outcome of which has been the present handy volume. Dr. Allman states that "it has been, throughout, my aim to state clearly the facts as known to us from the original sources, and to make a distinct separation between them and conjectures, however probable the latter might be." This testimony is, we believe, true: certainly the reader is put in possession of the facts so far as they are at this date obtainable.

We may just call to mind the points discussed. In an introduction the authorities on the early history are named: had Eudemus's history come down to us we should possibly have had a summary of the period treated of here, but now we are dependent upon Proclus. Then the work of Thales, of Pythagoras and his school, of Hippocrates of Chios, of Democritus, and of Archytas, is clearly discussed in Chapters I. to IV. In Chapter V., as we showed in a former notice, ample justice is done to Eudoxus, and his right place in the history of science is duly assigned. "In astrologia judicio doctissimorum hominum facile princeps," writes Cicero; in his "Histoire de l'Astronomie ancienne" Delambre has, "rien ne prouve qu'il fut géomètre"; and even De Morgan writes, "he has more of it [of fame] than can be justified by any account of his astronomical science now in existence." M. Marie is more just; though he devotes only two pages to the account of his work, he remarks, "il n'était pas au reste moins bon géomètre que bon astronome" (cf. Delambre, *supra*). Had Dr. Allman done no more than reinstate in its proper place a name "highly estimated in antiquity," this would have been a *raison d'être* for his work. We must remember, however, with regard to this tardy act of justice, that "it is only within recent years that, owing to the labours of some conscientious and learned men, justice has been done to his memory, and his reputation restored to its original lustre." In the following chapters (VI. to VIII.), we have accounts of the successors of Eudoxus, viz. Menæchmus, Deinostratus, and Aristæus. The concluding chapter takes up the work of Theætetus, and herein we have a discussion of the part which Euclid himself most probably contributed to his well-known "Elements."

All readers of this standard contribution to the early history of geometry, which has placed its author in the first rank of writers on the subject, and thereby brought credit to the whole body of English-speaking mathematicians, must hope that Dr. Allman will not lay his armour down, but that, after a brief respite it may be, he will undertake some such work again on a kindred subject. We would have suggested a careful edition of the text of Euclid had not labour in this direction been anticipated by Dr. Heiberg in his recently completed edition of the "Elements."

A bust of Archytas, from Gronovius, forms the frontispiece, a few notes are appended at the end to bring information as to books and editions up to date of issue, and a full index completes the volume.

One of the notes (p. 218) on "the theorem of the bride" is very interesting to us. On pp. 633, 637, of "Clifford's Mathematical Papers," we have given footnotes on the term "the figure of the bride's chair," which Clifford evidently used for a particular figure of Euclid i. 47. We had an idea at the time of writing the notes that the term ought to occur in Arabic, and so made application to Mr. Spottiswoode (a fair Arabic scholar himself), and through him to Oxford authorities, but no one could identify the expression. Dr. Allman notes: "M. Paul Tannery ('La Géométrie Grecque,' p. 105) has found in G. Pachymeres ('MSS. de la Bibl. nationale') the expression τὸ θεώρημα τῆς νύμφης to designate the 'theorem of Pythagoras.'" This seems to point to the old Egyptian idea as handed down by Plutarch (cf. Allman, pp. 29–32).

R. T.

OUR BOOK SHELF.

Die Meteorologie, ihrem neuesten Standpunkte gemäss, und mit besonderer Berücksichtigung geographischer Fragen dargestellt. Von Dr. Siegmund Günther. With 71 Illustrations. 304 pp. (Munich: Ackermann.)

DR. SIEGMUND GÜNTHER is already known by his "Lehrbuch der Geophysik," in two volumes, which appeared in 1884 and 1885, and runs up to nearly 1200 pages. The title of the present work is ambitious, and the endeavour to produce a text-book of the whole of meteorology in the space of 300 pages is a bold one. The work is a digest of existing text-books, such as Van Bebber's "Handbuch der ausübenden Witterungskunde," and Sprung's "Lehrbuch der Meteorologie." It is therefore excessively condensed, and to such an extent that it can only be used as a sort of index, for on all the subjects discussed, the reader is referred to other sources of information. The conception of the treatise is good enough, and the subdivisions are: (1) the general properties of the atmosphere, and observations thereon; (2) the movements of the atmosphere; (3) general climatology; and (4) the special climatology of the different zones. These are followed by two appendixes which might well have formed separate chapters; their subjects are, respectively, practical weather knowledge, and optical meteorology.

As might be expected, the sources of Dr. Günther's information are almost exclusively German, so that his *résumé* is slightly one-sided. This is especially the case when he is dealing with marine meteorology, as he almost ignores all work and all methods except those of the Deutsche Seewarte. In his notice of the marine barometer (p. 45), he entirely omits any mention of the principle by which the necessity for a capacity correction is dispensed with by the employment of a modified scale of inches. In speaking of the origin of weather telegraphy, Dr. Günther does scant justice to FitzRoy, who is merely casually mentioned as a former head of the English office. At p. 39 he gives the reader to understand that Kew, Pawlowsk, and Zikawei are the only stations in the world employing photographic self-recording instruments. A more serious slip, for a German, is at p. 243, where he speaks of two international Congresses at Leipzig and Rome, forgetting that the private meeting at Leipzig in 1872 was only preliminary to the Congress of Vienna in the following year. The correction of the press has not been carefully done: not only are letters dropped out in the printing of Latin and English words, but even in the German we have noticed several slips.

However, Dr. Günther's work is undoubtedly useful as indicating to geographers the main outlines of existing knowledge in the most important branches of science with which they come in contact at every turn, and also the lines in which further investigation is desirable.

Haunts of Nature. By H. W. S. Worsley-Benison. (London: Elliot Stock, 1889.)

SOME time ago we had the pleasure of recommending an excellent little book by Mr. Worsley-Benison, called "Nature's Fairy-land," consisting of a series of simple, pleasantly-written papers on some of those aspects of Nature which are most likely to excite the interest of children. The present volume has been planned on exactly the same lines, and is in every way worthy of its predecessor. In the opening essay the author describes the proceedings of two house-martins who did him the honour to select as the site for their nest a small wooden projection under the eaves of his roof. This paper has all the freshness and charm that spring from direct observation, and young people will read it with genuine pleasure. Among the subjects dealt with in other papers are wild roses, water scavengers, the dragon-fly's haunt, protective mimicry in insects, "fast asleep for months," and the ministry of leaves.

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 Structure and Distribution of Coral Reefs.

I AM somewhat disappointed that my criticism of Prof. Bonney's appendix in the last edition of Mr. Darwin's work on "Coral Reefs" has resulted only in an affair of outposts on the part of my opponents, since the main body of my arguments remains to be assailed. It would have been interesting, for instance, to obtain some further information concerning the evidence establishing the existence of the "90-fathom" reef of Rodriguez; and I should have welcomed the opinion of some zoologist as to the degree of our acquaintance with the fauna of the greater depths, say between 30 and 100 fathoms, around the shores of tropical islands in the Indian and Pacific Oceans. If this acquaintance is as scanty as I contend it is, then it is premature to fix the absolute limit of depth of the reef-coral zone.

At present, however, I shall be content with the establishment of the fact that corals occasionally grow in greater depths than 20 or 30 fathoms; and it was with this intention that I purposely singled out Commander Moore's observation in his Report on the Tizard and Macclesfield Banks. It is just this occasional greater depth of reef-coral growth that is the *crux* of the whole matter as far as the necessity for a theory of subsidence is concerned. Prof. Bonney admits in his last letter that "reef-building corals occasionally grow at depths considerably greater than 25 fathoms," and thus practically abandons the scanty foundation on which the surviving portion of the theory of subsidence now rests. My critic in this manner dispenses with the necessity of a movement of subsidence to explain the circumstance that lagoons are occasionally deeper than the usual limit of depth of the reef-coral zone, and to account for the occasional considerable thickness of upraised coral reefs. The supporters of Mr. Murray's anti-subsidence views will welcome this admission. It removes, in the first case, one of the chief points in favour of subsidence brought into prominence by Agassiz and Geikie in their hostile criticisms of the theory of Mr. Darwin—I refer to the abnormal depths of some atolls. In the second case, it shows that some of the evidence ranged in Prof. Bonney's appendix on the side of Darwin—I allude to that concerning the thickness of the upraised reefs of Cuba and the depth of limestone penetrated by the artesian borings at Oahu—should at least be placed in a neutral position. This is especially necessary in the instance of the artesian borings at Oahu, since Prof. Agassiz in his recent extensive memoir on the Hawaiian reefs,[1] which has not hitherto been quoted in this discussion, regards the borings from a point of view very different from the standpoint of Prof. Dana.

In this and in my previous letters I have shown to the best of my ability that nearly all the evidence ranged by Prof. Bonney on the side of Darwin should be placed at least in a neutral position. It almost all hinges on inferences that have not been established, or else on assumptions that cannot yet be proved. Surely the "90-fathom" reef of Rodriguez, if there has been no mistake in the matter, can be explained without subsidence by those who admit that "reef-building corals occasionally grow at depths considerably greater than 25 fathoms." The upraised reefs of Cuba must be placed on neutral ground. Masamarhu Island I have claimed for Mr. Murray. Lastly, there remain the artesian borings at Oahu; and, accepting Prof. Agassiz as our authority, we do not at present receive them as in favour of subsidence.

H. B. GUPPY.

June 11.

P.S.—After writing the above, I received a letter from Mr. John Murray, relating to the "90-fathom" reef of Rodriguez; he has kindly allowed me to quote from it the following remarks:—"I have examined all the charts and other available information, and have consulted some of the surveyors of the island. The result is that I don't think Prof. Balfour had sufficient grounds for stating with regard to Rodriguez that 'an older reef exists now quite submerged in some places to a depth of over 90 fathoms. Upon it the present reef rests, and it extends westward nearly fifteen miles from the present coast, while on the east it stretches

[1] Bulletin of the Museum of Comparative Zoology at Harvard College, vol. xvii., No. 3, April 1889.

about six miles' (Phil. Trans. R.S., vol. clxviii. p. 289; quoted on p. 308 of Darwin's 'Coral Reefs,' third edition). Here he evidently refers to the shallow water extending on all sides to the 100-fathom line, where there is about that depth a sudden fall. The fact is, such a character belongs to a large number of oceanic islands, whether surrounded by fringing reefs or no reefs whatever, and is due to quite other causes than reef-building."

June 14. H. B. G.

The Fireball of May 29, 1889.

THE fireball which I mentioned in NATURE of June 13 (p. 150) as having been seen at Leeds on May 29, was also observed at Belfast by Mr. I. W. Ward, who recorded the latter part of its course as from Vega to α Cygni.

Comparing this path with that assigned by Mr. D. Booth at Leeds, I find the radiant point at $214\frac{1}{2}^\circ - 7^\circ$, which was in azimuth 11° (west of south), and altitude $28\frac{1}{2}^\circ$ at the time (10h. 45m.) of observation.

When first seen at Leeds the fireball was situated over a point in the Irish Sea, in lat. 53° 58′ N., long. 5° 22′ W., and its height was sixty-one miles. At its disappearance it was six miles west-south-west of Stranraer on the coast of Wigtown, Scotland, at a height of twenty-five miles. The earth point was ten miles west of Troon, Ayrshire. The real length of path traversed was seventy-five miles, and the velocity eight and a third miles per second deduced from the estimated time of flight (nine seconds) at Leeds.

The radiant point at $214\frac{1}{2}^\circ - 7^\circ$ in Libra is situated near the earth's anti-apex, and the motion of the fireball would therefore be extremely slow, as it must have overtaken the earth in her orbit. It is curious that several doubly-observed meteors which have made their apparitions in the spring months have given the same radiant point. Thus the large fireball of May 12, 1878, seen in Scotland and the north of England had a radiant at 214° − 7° (Prof. A. S. Herschel). The conspicuous meteor of April 21, 1889, observed by Prof. Herschel at Croydon and the writer at Bristol, had a radiant at 218° − 5°. The vernal months appear to furnish us with a long-enduring shower from this special region of the zodiac. W. F. DENNING.

Bristol, June 15.

Meteor.

ABOUT 11.30 p.m. on the night of June 13, the sky being partially covered with fleecy clouds slowly drifting from the south-west, so that the full moon was frequently obscured, a shooting-star appeared in the north, at an elevation of about 50° to 60°, and descended obliquely towards the east. It was as bright as a star of the first magnitude, and was visible during a slightly zigzag flight of some 30°, leaving no trail. But the remarkable thing was that the sky in that quarter was pretty closely covered with the slowly-moving fleecy clouds, so that no fixed stars were visible. The meteor, therefore, must have been below the clouds, at least in the latter part of its course.

Birstal Hill, Leicester. F. T. MOTT.

Stationary Dust-Whirl.

YESTERDAY morning, at 9.30, I was fortunate in witnessing a stationary dust-whirl, about a hundred yards from where I stood, on a dust-covered highway lying due east and west. The morning was warm, 67°·5 in the shade, barometer at 30·06, and the sky clear, excepting a few isolated cumulus patches. The air was still, the wind-vane indicating north-west. The appearance of the whirl presented a resemblance to a fountain of water playing, only the base was broader than the upper part, which was perfectly columnar. It remained, for nearly five minutes, absolutely stationary, then suddenly ceased, recommencing for a few seconds, on a much smaller scale, some ten yards westwards. Its height, when at its best, would be about 25 feet, and its diameter, midway, 2 feet. I could not correctly ascertain the spiral motions of the whirl, but judged the outer spiral to move from west to east, and upwards. The wind jumped round into the north-east shortly afterwards, with clear sky, and the barometer steadily rising. No others were seen during the day. J. LOVEL.

Driffield, June 17.

Bunsen's Photometer.

IF we place the "grease-spot" screen between two sources of light, situated at A and B, whose intensities are I and I′ respectively, and if C be the position of the screen for which the spot disappears when viewed from the side towards A, and C′ the corresponding position when viewed from the other side, it is usual to say: Take the mean of AC and AC′, and the mean of BC and BC′; the squares of the means will be approximately proportional to the intensities.

The relation

$$\frac{I}{I'} = \frac{AC \,.\, AC'}{BC \,.\, BC'}$$

is more exact, as may be shown by the following:—

Let a be the fraction of the light falling on unit area of the spot from A which reaches the eye, and b the corresponding fraction for the dry part; and let c and d be the respective fractions of the light falling on the other side of the paper, which, after passing through, reach the eye. Then, since the spot and the dry part in the position C are equally bright when viewed from the side towards A, we have, equating the light per unit area from the two parts—

$$\frac{I}{AC^2}a + \frac{I'}{BC^2}c = \frac{I}{AC^2}b + \frac{I'}{BC^2}d,$$

or

$$\frac{I}{AC^2}(a - b) = \frac{I'}{BC^2}(d - c) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If C′ be the position of the screen for which the parts appear equally bright, as seen from the other side, we have—

$$\frac{I}{AC'^2}c + \frac{I'}{BC'^2}a = \frac{I}{AC'^2}d + \frac{I'}{BC'^2}b,$$

or

$$\frac{I'}{BC'^2}(a - b) = \frac{I}{AC'^2}(d - c) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From (1) and (2)—

$$\frac{I}{I'} = \frac{AC \,.\, AC'}{BC \,.\, BC'}.$$

If $a + c = b + d$, we see that C and C′ must coincide. This condition implies that the light lost is the same for the spot and for its surroundings.

In the method of using the photometer, in which the two lights to be compared are balanced successively against a third light, and the spot in both cases is viewed from the same side, the inequality of the portions of light lost by the two parts does not disturb the result. D. M. LEWIS.

University College, Bangor, June 6.

THE TUTICORIN PEARL FISHERY.

AFTER an interval of more than twenty-seven years, the pearl-oyster (*Avicula fucata*, Gould) has produced pearls off the Madras coast of the Gulf of Manaar, in sufficient quantities to be worth the expense of fishing. The last fishery of the Tuticorin banks took place in the years 1860-62, and resulted in a net profit to Government of Rs. 3,79,297 (£37,929 at par). In olden times, when Tuticorin was in the possession of the Portuguese and Dutch, the fishery used to be carried on much more frequently than it is at the present day, and a difficult problem, which remains to be solved, is, What are the causes of the decline of the pearl fishery, and how can the Tuticorin banks be made to yield a more frequent harvest? Whether the baneful influence of the Mollusca known locally as *sooram* and *killikoy* (Modiota sp., and Avicula sp.), the ravages of the file-fishes (Balistes) and Rays (Trygon, &c.), poaching, or currents, are responsible for the non-production of an abundant crop of adult pearl-producing oysters during more than a quarter of a century, it would be impossible to decide until our knowledge of the conditions under which the pearl-oysters breed, develop, and live, is more precise than it is at present.

Superstition, as of old, still clings to the native divers; and I read, in a recent issue of the *Times of Ceylon*, that "at present there are said to be 150 boats, with their full complement of men, all waiting at Kilakarai in readiness to proceed to Dutch Bay, but they will not leave until after some festivities which occur on the 15th instant, when it is customary for them to pray for protection from sharks, &c., while engaged in diving." I can find no record of a diver being killed, in recent years, by a shark. But a case is cited, in which a native died at Tuticorin from the poisonous stings of a jelly-fish. At certain seasons of the year, jelly-fish are very abundant in the Tuticorin harbour, and a resident merchant tells me that, so great is the dread of them among the natives, that he has known coolies, engaged in carrying loads of palmyra jaggery through the shallow water to the cargo-boats, refuse to enter the water till a track free from jelly-fish was cleared for them by two canoes dragging a net between them.

The pearl-bank which is being fished at the present time, is known as the "Tholayiram Par," which covers an area of about five square miles, and lies more than ten miles east of Tuticorin, in from 8 to 10½ fathoms. The following record, by the Superintendent of the Pearl Banks, shows the condition of this bank as regards oyster-supply from the year 1860 to 1884, the oysters which are now being obtained having been first noticed at an early stage of growth in the latter year:—

April 1860.—Plenty of oysters three and a half years old.
November 1861.—Oysters scarce; nearly all gone.
April 1863.—*Sooram* and *killikoy* with some young oysters.
November 1865 to April 1869.—Blank.
March 1871.—Five oysters with a quantity of *sooram*.
February 1872.—Five oysters of three years old found.
May 1873.—Three oysters found.
January 1875.—Three oysters of two years old found.
March 1876.—North part blank.
April 1877.—South part blank.
April 1878.—Thickly stocked with oysters one year old.
May 1879.—Blank.
May 1880.—Blank.
May 1881.—Some oysters mixed with *killikoy*.
May 1882.—No oysters; dead shells and *sooram*.
April 1883.—Three oysters found.
March 1884.—Plenty of oysters one year old; clean and healthy.

This record shows very clearly how capricious is the life of the pearl-oyster, how easily the hopes of a productive bank may be banished (witness the total disappearance of the oysters in 1879), and points to the evil influence of *sooram*, which, spreading in dense masses along the rocky bottom, crowds out the young pearl-oysters.

Since 1884, the "Tholayiram Par" has been carefully watched, and the growth of the oyster, from the young to the adult stage, has steadily advanced.

				Ounces.
Ten oysters lifted,		March 1884,	weighed	1
,,	,,	October 1884,	,,	3¾
,,	,,	March 1885,	,,	6¼
,,	,,	October 1885,	,,	7
,,	,,	April 1886,	,,	7½
,,	,,	November 1886,	,,	8½
,,	,,	March 1887,	,,	10¾
,,	,,	October 1887,	,,	13
,,	,,	November 1888,	,,	15¼

In November last, 15,000 oysters were taken from the bank for the purpose of valuation by pearl-merchants, and the product was valued at Rs. 13,12,8 per 1000 oysters.

The shells of the oysters which are now being brought in daily are incrusted with various marine animals (Sponges, Polyzoa, &c.), and enveloped in masses of delicate Algæ; but, among very many thousands which I have examined, I have met with no *sooram*, and only very few specimens of *killikoy*. The oysters are living either on sand, by which they are partially buried, or on coral rocky ground (Turbinaria, Montipora, Porites, &c.), and are often brought up attached by their byssus to dead branches of Madrepores, or *Melobesian nodules*. Large specimens of the big *anai mullu shanku* (Murex sp.) are frequently brought up by the divers, and the tough animal, when removed from the shell, is served up for the evening meal.

The improvised camp, from which the fishery is conducted, is situated on the coast about two miles north of Tuticorin, and, on the way thither across a long stretch of sand, the kilns in which coral and shells are converted into *chunam* are passed, and the chank godowns, in which the chanks (*Turbinella rapa*), whose shells afford an annual source of revenue to Government, are stored, the animal matter being got rid of by the combined influence of insects and bacteria. The camp, which is built of bamboo and palmyra, is made up of residential huts, tents, and bungalows, offices (treasury, dispensary, &c.), sheds called *kottoos*, in which the oysters are counted and submitted to the unsavoury washing process, and the native *bazár*, gaily decorated with flags, in which the product of the oysters is exposed for sale.

As soon after midnight as the land wind sets in, the signal gun is fired on the shore by the native beach master, and, amid a good deal of shouting, all sail is set, and the fleet, which is unfortunately composed of less than fifty boats, with its complement of divers, makes for the bank, which should be reached by daylight. The hoisting of a flag on the schooner which is stationed on the bank is the signal for the day's fishery to commence. The limits of the entire bank are marked out by buoys, and the divers are supposed only to work, on any given day, over an area which is also indicated by buoys; but, owing to adverse winds and other causes, it is sometimes found impossible to keep the boats within the prescribed area. A stone, to which a rope is attached, is put over the boat's side, and a basket or net fastened in a similar way. These ropes the diver takes in one hand, and, placing one foot on the stone, he draws in a deep breath, closing his nostrils with his other hand; or the nose is inserted into a clip, which tightly compresses the nostrils. At a given signal the ropes are let go, and the diver descends to the bottom. The slacking of the ropes shows that this is reached. The diver then lets go the stone, which is drawn up to the surface, and, after filling the basket or net with oysters, he ascends to the surface to regain his breath. The divers work in couples, two to each stone, and the oysters brought up are kept carefully separated from those of other divers. The other day 237,000 oysters were brought up by 454 divers, in about 5½ hours, giving an average of 524 oysters to each diver. A European diver is engaged experimentally on the bank, but his greatest haul in a day has been only 1500 oysters.

The diving operations cease for the day about 1.30 p.m., and the boats start for the land, the signal gun being fired and the Union Jack run up on the flagstaff as soon as they are sighted. On reaching the shore the boats are secured, the oysters carried to the shed, rapidly counted, and divided into three heaps. The superintendent of the fishery, or some other responsible officer, touches with his stick one of these heaps, which becomes the property of the divers, who receive a pass and carry their hard-gained earnings outside the shed, where a swarming crowd of natives is waiting, eager to try their luck by purchasing a few oysters at a rate varying from about fifteen to forty for a rupee. Until long after dark crowds of natives may be seen squatting in circles on the sand, opening their oysters and carefully examining the flesh with a knife in search of even the smallest pearls. The utmost good temper prevails, and the possessor of only a few seed pearls is, apparently, perfectly happy. The two heaps which are left by the divers constitute the Government share, and are carefully counted by Government coolies. The beating of the *tom-tom* then announces that the Government auction is about to commence. The oysters are put up for sale in lots of 1000, and the purchaser has the option of taking a certain number of thousands at the same rate. As soon as the purchase money has been paid, the oysters are handed over to the purchaser, who sends them off by train, or deposits them in the *kottoo* at the northern end of the camp, where various natural agents bring about the requisite process of dissolution of the animal matter. After some days the residue is carefully washed, the prevailing maggots skimmed off, and a careful search made for the pearls.

Pearl Camp. EDGAR THURSTON.

CALIFORNIAN FORESTRY.

IT is matter for great satisfaction to learn that the "people of the State of California represented in Senate and Assembly" have created a Board of Forestry for the purpose of collecting and diffusing information with regard to forestry, tree-culture, and tree-preservation. The readers of NATURE will not fail to appreciate the economic significance of wisely administered forest laws so far as those laws are based upon scientific knowledge, and there are special reasons why they should feel an interest in the forests of the Pacific slope. They will consequently be glad to learn from the second biennial Report of the State Board of Forestry now before us that whereas, "under the old conditions, waste, destruction, and violation of law were rife, . . . the activity of the Board in attempting a reform, and the consequent investigations of the Government, have had a most gratifying result." Fires have been reduced in frequency and extent, watersheds and springs have been protected, slopes saved from further denudation, and replanting effected. It seems strange that, with so great a wealth of native trees, replanting should have become necessary, and still more that the Eucalypts of Australia should be preferred for this purpose to the pines of the Sierras. Nevertheless there are many sites where drought-resisting trees are specially required, and in which some of the Eucalypts, such as *viminalis* and *corynocalyx*, do better than the pines. Experimental stations have been established under different conditions of soil and climate, survey-maps have been constructed, while in the Report now before us a beginning has been made of a scientific and popular description of the forest trees of California. The preparation of this catalogue has been intrusted to Mr. J. G. Lemmon; its illustration will be undertaken by Mrs. Lemmon, and by photographs. For botanical purposes the writings of Engelmann, Sargent, Watson, Parry, and others in recent times, of Sir W. Hooker and Dr. Arnott at a more remote period, will supply what is needed.

Mr. Lemmon waxes enthusiastic, as well he may, over the forests of California. Pre-eminent over all forestal regions of the earth are the dense and extensive tree-growths clothing the slopes of that most diversified and wonderful of mountain-ranges—the Sierra Nevada of Western America—a range distinguished by the abruptness of its majestic uprise from the plain, the splintered and rough-hewn forms of its thousand peaks, the high elevation of their pinnacles ever bearing their crowns of snow, but most of all pre-eminent for its bounteous and beautiful "enrobing forest, . . . the noblest in North America, perforated along its raised centre-line by a thousand peaks rising through the mantle into perpetual winter; while both slopes, east and west, are rent by a million valleys, depressed through the robe (of forest) into the middle region of changing seasons, and the fringe of the garment trails out over the domain of almost perpertual summer." In a similar strain Mr. Lemmon proceeds at considerable length and in a style we are not accustomed to meet with in "Blue-books." The Sierra forests, so far as environment is concerned, occupy a middle position between torrid and frigid conditions. They are composed mainly of evergreen trees, not one of which is specifically identical with the trees on the Atlantic side of the Continent, though often so curiously alike that each genus has its "representative species" on either side. The "big trees," *Sequoia gigantea*, or *Wellingtonia*, have been written about so often that most people are familiar with them. "Far excelling them in loveliness" are the four species of *Abies—nobilis, grandis, magnifica*, and *concolor*. These are all, with many others, cultivated in our parks and gardens, where they thrive better as a rule than in the Eastern States of America. Already they justify in a measure Mr. Lemmon's ecstasies; though it is probable that their beauty will not be enhanced as they grow old, for many of these trees which are pictures of grace and beauty when young become "scraggy" and unlovely when old. Fortunately the standard of age is different in trees and men, and some generations of men may pass before the trees lose their charm. Of their value as timber trees in this country we need not speak here; indeed, little definite is yet known; but, at any rate, there are well-founded hopes in the case of the Douglas fir, the Nootka Sound cypress, *Thuya borealis*, the *Thuja gigantea*, and some others which seem destined to play an important part in the forestry of the future.

After some generalities Mr. Lemmon proceeds to give a classification of the true pines (*Pinus*), of the Pacific slope, a classification intended for popular purposes, and therefore one in which the histological characters of the leaves are passed over. The main divisions are into smooth-coned pines and rough-coned pines, corresponding to the sections *Strobus* and *Pinaster* respectively. In the one the scales of the cone end in thick, prominent, often spiny bosses, in the other the ends of the scale are nearly flat or project but little. Then comes a subdivision according to the length of the cone, surely a most untrustworthy criterion; for instance, Lambert's pine, the gigantic sugar pine, bears cones varying from 10 to 22 inches in length according to Mr. Lemmon's own showing. Further subdivisions are founded on the position of the young cone near the terminal leaf-bud or at some distance from it, on the length of time the cones remain on the tree, the way in which the scales eventually separate, and so forth. Having characterized the various species of *Pinus*, the author proceeds to give detailed information about each. This is the most valuable portion of Mr. Lemmon's report for European botanists. We would fain make many quotations, but our space allows us only to mention two species. The magnificent sugar-pine (*Lambertiana*), was first made known by Douglas. It sends up a magnificent shaft two hundred feet high, and sometimes much more. The value of this tree for "lumber" purposes is as great as its stateliness is imposing, hence thousands of noble trees have been shamefully destroyed. "Lawless vagabonds penetrate the Sierra forests with only the equipment of an axe and a long saw, and, levelling these monstrous trees, they saw out a cut, examine it, and perchance move on to the destruction of others, leaving to rot on the ground trees that would yield to the careful lumberman twenty thousand to fifty thousand feet of clear lumber, worth hundreds of dollars." *Pinus Torreyana*, the lone pine, also deserves special notice here as a species of much structural interest, and as one which, it appears, is on the high road to extinction, unless that process can be obviated by forest ordinances or by the care of the cultivator. On the coast of Southern California, on the bluffs at Del Mar, San Diego County, within a range of four miles only, and nowhere else so far as known, are a few small trees, buffeted and often prostrated by ocean winds, clinging to the face of crumbling yellow sandstone. On the sheltered inner side of the hills and on the spurs of the cañons, bathed with frequent sea-fog, the trees have indeed a better chance, and they accordingly there form a trunk some thirty or even fifty feet in height, capped with a spreading crown. The leaves are in fives, as in many of the Mexican pines, and the cones have thick scales, each terminated by a short strong prickle. "In many respects this species of pine stands alone among Californian Conifers. No other species is found within fifty miles of it; none other survives such buffetings by the sea winds, and no other bears such large flowers, hard nuts, and such strong leaves. . . . In the few localities young trees of all ages are found, but always less in number than the older trees, from which it is inferred that the species is slowly succumbing to its environment, and must if not protected soon become extinct." Such a tree, apart from its interesting structure and history, would be a valuable introduction as a sea-coast pine, wherever the climatal conditions are otherwise favourable.

The Report from which we have taken these particulars is illustrated by photographs, which, if not in all cases very clear, at least show fairly well the general habit of the trees. For details of structure they are not so well suited, and we trust that in future Reports some other means may be taken to give adequate representation of such details. We look forward with eagerness to the continuation of the history of the Californian trees, the silver firs, the Douglas firs, and others that yield in no respect to the pines.

THE EXTINCT STARLING OF RÉUNION (FREGILUPUS VARIUS).

TIME alone can prove whether we are right in calling the *Fregilupus* an extinct species, for many people have imagined that the bird still exists in the interior forests of the Island of Réunion; but as year after year passes by and no specimens are discovered, we fear that we must class the starling of Réunion, along with the Dodo and other birds of the Mascarene Islands, as having been exterminated by the hand of man.

The earliest mention of the *Fregilupus* is believed to be that of Flacourt, who, in an account of a voyage to Madagascar, speaks of a bird called the "Tivouch," found in Madagascar, Bourbon, and the Cape, and described as being "black and grey, with a fine crest." The species was for a long time supposed to inhabit the Cape, and Montbeillard calls it the "Huppe noire et blanche du Cap de Bonne Espérance." Its crested head and curved bill were evidently the cause of the bird being called a Hoopoe, as was done by most of the older writers, until Levaillant in 1806 put it down as a *Merops* or Bee-eater. The latter author knew of eight specimens at least, two in the Paris Museum, one in the possession of each of the following persons, MM. Gigot Dorey, Mauduit, l'Abbé Aubry, M. Poissonier, one in the collection of M. Raye, at Amsterdam, and one in Levaillant's own collection. The fate of most of these specimens is unknown at the present day; they have doubtless decayed or been destroyed, as the mode of preservation of animals at the beginning of the century was by no means perfect.

In 1833 a very fine specimen was sent by Mr. Nivoy to the Paris Museum, where we saw it a few days ago, along with a more ancient individual, doubtless one of the two known to Levaillant. The same Museum also possesses two specimens in spirit. The only representative of the genus *Fregilupus* in this country has hitherto been a skeleton in Prof. Newton's possession. This individual was shot in 1833 by the late Jules Verreaux, who gave it to Prof. Newton. We are happy to announce, however, that the Trustees of the British Museum have recently acquired a very fine example of this extinct starling, one too which, curiously enough, was not known to Dr. Hartlaub when he gave in 1877 the list of specimens supposed to exist in Museums. The bird now in the Natural History Museum has been acquired from the well-known Riocour collection at Vitry-la-Ville. This famous collection, the work of three generations of the Counts De Riocour, consisted of a series of excellently mounted specimens, forming a choice little Museum which it would be hard to excel. The grandfather of the present Count was the founder of the collection, and was an intimate friend of Vieillot and the old French naturalists at the beginning of the century. Nearly all the specimens of that age are named by Vieillot, several of whose types are in the Riocour collection; and Dr. Günther has been successful in securing these also for the cabinets of the British Museum. A more interesting link with the past than this collection of the Counts De Riocour can scarcely be imagined, and we are glad to know that in the hands of Mr. Boucard, who is now the owner of the collection, it will receive the kindly consideration which such a famous Museum deserves.

Writing in 1877, Dr. Hartlaub, in his "Vögel von Madagascar's," gives a list of the specimens of *Fregilupus* known to him, as follows:—Four in the Paris Museum (two stuffed and two in spirits); one in the Caen Museum; one at Leyden (old and bad); one in the Stockholm Museum; one in the Museum at Florence; one in the Pisa Museum; one in the Genoa Museum; one in the Turin Museum; and one in the collection of Baron de Selys-Longchamps.

Sir Edward Newton likewise knew of two specimens in the Museum at Port Louis in Mauritius, and there is also the skeleton in Prof. Newton's possession; so that, with the one recently added to the British Museum, there are probably sixteen specimens in existence. The Italian Museums received their specimens from the same source, viz. from Prof. Savi at Pisa; and some of those in other Museums are from the same source. Count Salvadori has published a very interesting article on the *Fregilupus*, in which he informs us that Savi received several specimens from a Corsican priest named Lombardi, and that these specimens were given away by Savi in the most generous spirit, as he appears to have retained only a single specimen for the Pisa Museum.

Like other insular forms, the *Fregilupus* seems to have courted extermination by its very tameness and ignorance of danger. The late Mr. Pollen stated in 1868 that the species had become so rare in Réunion that when he visited the island not one had been heard of for ten years, though it was still believed to survive in the forests of the interior. The old people who remembered when the birds were still common told him that they were so stupid and fearless that they could easily be knocked down with sticks.

The extinct *Necropsar rodericanus*, Slater, was the representative of *Fregilupus* in Rodriguez (cf. Günther and E. Newton, Phil. Trans., vol. clxviii. p. 427), and its nearest living ally of the *Fregilupus* is probably *Falculia* of Madagascar, but there is also considerable affinity to *Basileornis* of Celebes and Ceram. An excellent account of the osteology of the genus was given by Dr. Murie in the Proceedings of the Zoological Society for 1873.

R. BOWDLER SHARPE.

A MANSION HOUSE MEETING IN AID OF THE PASTEUR INSTITUTE.

THE Lord Mayor has fixed July 1, at 3 p.m., at the Mansion House, for a public meeting to hear the statements of scientific and medical men with regard to the prevention and cure of hydrophobia. Sir James Paget has promised to address the meeting, and it is expected that Sir Henry Roscoe, Dr. Lauder Brunton, Sir Joseph Lister, Prof. Ray Lankester, Sir Joseph Fayrer, Mr. Victor Horsley, Mr. Everett Millais, and others will take part in the proceedings. All scientific men interested in M. Pasteur's discoveries are earnestly requested to attend and support the Lord Mayor. The following resolutions will be moved:—

1. "That this meeting desires to express the gratitude of the people of Great Britain and Ireland to M. Pasteur and the staff of the Institut Pasteur for the generous aid afforded by them to over 200 of our fellow-countrymen suffering from the bite of rabid dogs."

2. "That this meeting, having heard the statement of Sir James Paget and others, records its conviction that the efficacy of the anti-rabic treatment discovered by M. Pasteur is demonstrated, and requests the Lord Mayor to establish a fund for the double purpose of making a suitable donation to the Institut Pasteur, and of providing for the expenses of British subjects unable to pay the cost of a journey to Paris when bitten by rabid animals."

3. "That this meeting, whilst recognizing the value of M. Pasteur's treatment, and taking steps to provide for its accessibility to Englishmen who may hereafter be bitten by rabid animals, is of opinion that rabies can easily be stamped out in these islands, and calls upon the Government to introduce at once a Bill for the simultaneous muzzling of all dogs throughout the British Islands, as provided in the measure drafted by the Society for the Prevention of Hydrophobia."

NOTES.

THE King of Sweden has invited Prof. Max Müller, the representative of Oxford, to be his guest at the Royal palace in Stockholm during the forthcoming Congress of Orientalists. Some 500 foreign members will attend the Congress. During the visit to Christiania, King Oscar will give a banquet to the members of the Congress at his villa at Bygdö, and the city has voted the necessary funds for a civic entertainment.

PROF. A. C. HADDON, whose movements in the Torres Straits we have from time to time recorded, is now on his way home. Contrary to the expectations of his friends and well-wishers, illness has overtaken him; but, as he writes from Brisbane, hope for the best would appear justifiable. He has worked indefatigably during his sojourn in the tropics, and has accumulated a vast collection, the greater part of which is now safely delivered.

MR. HENRY WILLIAM BRISTOW, F.R.S., died on Friday last at the age of seventy-two. In 1842 he was appointed a member of the staff of the Geological Survey of the United Kingdom. Mr. Bristow published various works on mineralogy and geology, and was the author of the mineralogical articles in Brande's "Dictionary of Science, Literature, and Art," and of articles on minerals and rocks in Ure's "Dictionary of Arts, Manufactures, and Mines." He became a Fellow of the Geological Society in 1843, and of the Royal Society in 1862, and an honorary Fellow of King's College, London, in 1863. He received the diploma of the Imperial Geological Institute of Vienna, and from the King of Italy the diploma and insignia of an officer of the Order of SS. Maurice and Lazarus.

SIR JOHN LAWES entertained the members of the Lawes Agricultural Trust Committee at Rothamsted on Friday last. In the afternoon the Committee inspected the experimental farm and the laboratories connected with it.

THE Geologists' Association propose to organize a geological excursion to the volcanic regions of Italy—Naples, Sicily, and the Lipari Islands, or to some of these places if not to all of them—during the month of October next. This excursion, in which ladies may take part, is not confined to members of the Association, and at the meeting of the Geological Society on June 5, Prof. Judd announced that the authorities of the Geologists' Association particularly invite the attendance of Fellows of the Geological Society.

A ROSE CONFERENCE will be held in connection with the Royal Horticultural Society at Chiswick on July 2 and 3. According to the official programme, the objects of the Conference are "to get together as large and as representative a collection of roses of all descriptions as possible; to form an Exhibition of all subjects pertaining to the rose, whether in its botanical, its horticultural, its literary, or its artistic aspects; and to bring together for the purposes of reciprocal information and fellowship all those interested in the rose and its culture." The Royal Horticultural Society appeal to lovers of the rose to help them to attain these ends.

ON Wednesday, July 10, the annual meeting of the Society of Chemical Industry will take place in the theatre of the Royal Institution at 11 a.m. In the evening the President will hold a reception and *conversazione* in the Grosvenor Gallery. On the two following days there will be various visits and excursions, and on the evening of July 11 the annual dinner of the Society will be held.

IN connection with the bequest of the late Dr. Swiney, Prof. W. R. McNab, of the Dublin College of Science, will begin a course of twelve lectures on fossil plants at the Natural History Museum, Cromwell Road, on Monday, the 24th inst. The subject will be continued from the course of last year, and will include the Ferns and Gymnosperms of the Palæozoic and Mesozoic epochs, and the dawn of the Angiospermous flora. The lectures will be given on Mondays, Wednesdays, and Fridays at half-past four o'clock, and will be free to all visitors to the Museum.

THE Indian Government has purchased the coins collected by the Afghan Boundary Commission. They are over 4600 in number, and are to be catalogued by Mr. C. J. Rogers, of Amritsar.

THE Russian Academy of Sciences offers a prize of 5000 roubles (£500) for the best inquiry into the nature and effects of the poison which develops in cured fish. The objects of competitors must be: "(1) To determine, by means of exact experiments, the physical and chemical nature of the poison which develops in fish; (2) to study, by experiments on animals, its action upon the heart, the circulation of the blood, the organs of digestion, and the nervous system; (3) to determine the rapidity of its absorption by the digestive organs; and (4) to study and describe the characteristics which may serve to distinguish contaminated fish from such as are not contaminated." The fifth and sixth questions, with which it may be impossible for any one to deal satisfactorily, relate to the means of preserving fish from the development of the poison, and to the question of counter-poisons and the medical treatment of poisoned persons. The competition is open to all. The memoirs must be sent in, either in manuscript or printed, before January 1, 1893, and may be written in any one of the following languages: Russian, Latin, French, English, German. If none of the papers is deemed worthy of the full prize, the accumulated interest upon the above-named sum may be handed over to the author who presents the best solution of some part of the problem.

A RECENT issue of the French *Journal Officiel* contains the Report of the Consultative Committee for Sea Fisheries in France on the subject of poisoning through the eating of mussels. The Committee, in the first place, recognize that the oysters which cause poisoning are those which have become stale, or have been kept in water rendered foul by decomposed organic matter, and question whether the same may not be the case with regard to mussels. Various explanations of mussel poisoning were made to the Committee. By some it was attributed to a parasite crab (*Pinnotheres pisum*). This explanation, however, was unsatisfactory, for in the United States this *Pinnotheres* is sought after as food. By others, the presence of the poison was attributed to the spawn of star-fish, and also to copper absorbed from wrecks. Both these suggestions were, however, disproved. The theory of Orfila, also, that the poisonous action of the mussels in the stomach is the result of imagination, does not find acceptance at the hands of the Committee. An authority on the subject has found that the mussels lose their poisonous property if cooked for a period of ten minutes with carbonate of soda. The Committee conclude that the poisonous nature of the mussels is due to the presence in them, especially in the liver, of a volatile organic alkaloid (*mytilotoxine de Brieger*), developed under the influence of a particular microbe, which is only found in mussels living in stagnant and polluted waters. Finally, they advocate the removal of all restrictions on mussels in artificial beds, and recommend the sale at all times, at fish markets, of mussels coming from such beds, which are usually situated in favourable localities, a sale which is at present prohibited in France during May and June.

MR. TUPPER, the Canadian Minister of Marine and Fisheries, is reported to be now arranging for the establishment at Halifax of an Intelligence Department, for the purpose of supplying fishermen on the Atlantic coasts with information as to the movement of the various food and bait fishes. Bulletins will be issued frequently upon the subject, and will be widely circulated, and in addition fishermen will always be able to obtain, by means of a telegram or letter, any reasonable information they may require regarding their industry.

THE Cornell University has found in Mr. Henry W. Sage, of Ithaca, a friend whose good-will reveals itself in a very practical manner. A suit is now going on, involving $1,500,000, bequeathed to the library of Cornell. In the event of the suit being lost, Mr. Sage proposes to pay for the library building—to cost over $200,000—on which work has begun; and also to give the library an endowment of $300,000. Should the suit be won, as is confidently expected, Mr. Sage's half a million will probably go to the University for other purposes. *Science* says that the giving of this sum will make Mr. Sage's benefactions to the University amount to about $1,000,000 in cash. The institution also owes much to him for counsel and services.

ON June 12, Dr. A. B. Meyer, of the Zoological and Ethnographical Museum at Dresden, received from Prince Ferdinand of Bulgaria a telegram announcing that immense numbers of the bird called *Pastor roseus*, L., had arrived some days before at Knjajevo, near Sofia, and were still there. The usual haunts of *Pastor roseus* are in the valleys of the Danube, in South Russia, and in the neighbouring districts of Asia; but this year it seems to have extended its range, and Dr. Meyer announces that he will be glad to receive any information that may be sent to him as to its appearance in new neighbourhoods. Between 1774 and 1875 the bird is said to have been seen in Germany thirty-one times, in Switzerland sixteen times. In June 1884 it was seen in Bavaria, and in the autumn of the same year in Würtemberg. It appeared again in Bavaria in May 1886. Until the other day it has not visited Bulgaria since 1876.

A LARGE meteoric stone which recently fell in Scania has been acquired by Baron Nordenskiöld for a sum of £84 for the National Museum.

ON May 31, about 11 p.m., a brilliant meteor was seen at Ljungby, near the Sound. It went in a direction east to north, emitting a bright red colour, and was accompanied by a distinctly audible hissing.

IN reference to the destructive volcanic eruption on the Island of Oshima (better known to the Western world as Vries Island), of which information has been telegraphed from San Francisco, it seems that the first news of it was brought to Yokohama by the master of a passing steamer, who described the mountain Miharaizan as being in fiercely active eruption on the morning of April 13. The eruption was of such a nature that it attracted attention on board the steamer at a great distance. Afterwards it was ascertained that the outbreak was at the western base of the mountain. From this it would appear that a new crater has been formed, as the old crater is at the top of the mountain, though there is a place to the south-west whence smoke is always issuing from the sands. The *Japan Weekly Mail*, from which this information is taken, gives the following historical account of this remarkable volcanic island. Miharaizan, according to the oldest Japanese historical records, was an active volcano so far back as 684 A.D., but the earliest authentic notice of its activity appears to have been taken in 1421, when the sea boiled, and the fish died in shoals. In 1684 an eruption commenced which lasted seven years, and in 1703 there was a great earthquake and tidal-wave, and part of the island broke down and formed the present harbour. In 1777 the mountain was in active eruption, and the island was covered several inches deep with ashes, such phenomena being almost constantly repeated from that date till 1792. It was then quiet till 1837, and more or less in action for the following twenty years. Another lull then took place, when, in 1868, it again broke out, and continued in action four days. The next eruption occurred in 1876, and lasted nearly two months. The most destructive eruptions of Miharaizan were probably those of 1781 and 1789, as, during the latter, the village of Shimotaka was entirely destroyed, and the people and their houses were completely buried in ashes. There are at present six villages on the island, containing a population of 5000 persons, mostly fishermen.

REPORTS from New Zealand describe a recurrence of volcanic activity in Mount Ruapehu. On April 29 an enormous cloud of steam was seen ascending from the summit. There is said to be every indication that considerable thermal activity is going on in the hot lake on the summit, as the outburst was of the nature of a colossal geyser ascending rapidly and subsiding in a few minutes. Since the terrible eruption at Tarawera in 1886, any new outburst, of however trifling a character, naturally gives cause for much alarm all along the belt of volcanic country from Rotorua to Tongariro and Ruapehu.

THE Pilot Chart of the North Atlantic Ocean, published by the Hydrographer of the United States, shows that the month of May was characterized by generally fair weather, and, with the exception of one day, by the absence of storms of great violence. Much fog was encountered during the month, and seriously interfered with commerce in the vicinity of New Jersey and New York. Icebergs were met with in large quantities between longitude 40° and 51°, north of latitude 46°. The approach of the hurricane season in the West Indies was marked by two well-defined depressions on the 4th and 17th respectively.

IT appears that the somewhat eccentric weather of Western Europe during the present year finds a parallel both in China and Japan, where people complain bitterly of the sudden changes of temperature, the premature heat followed by cold "snatches," the storms in quick succession and of great intensity. Thus, the *Chinese Times* of Tientsin, one of the most northern parts of China, says that since foreigners have had any connection with the place there has not been known such an inclement spring. A warm week in February broke up the ice on the Peiho River prematurely, but afterwards cold set in with great severity, and March was characterized by a succession of gales, lasting sometimes a week without intermission, and as late as the 24th the ground was covered with snow. As a rule, the country people never can have enough of snow, which they consider has a most benignant effect on the soil, but the snowfall this spring was so unusual that at last the farmers cried out that they had had too much of it.

THE *Glasgow Herald* states that last year, while some workmen were engaged in drainage operations at Lochavullin for the purpose of forming a public park, they discovered what was believed to be an old "crannog" or lake-dwelling, and several experts who visited it were of opinion that it was a very good specimen of an ancient lake-dwelling. Arrangements were made by the Town Council for its being properly investigated and preserved as far as possible, but the weather has rendered operations impracticable till within the last few days. Workmen are now engaged in excavating round the place, and recently it was visited by Mr. Cochran-Patrick, Under-Secretary for Scotland, and other gentlemen interested. Among the articles turned up by the workmen during the examination were a stone bullet, such as would have been used in the slings of the period to which the dwelling is supposed to have belonged, and portions of the wattle used in the construction of the dwelling. Prof. Hedley, of St. Andrews, took some photographs of the place.

MR. H. B. CRESSON, of Philadelphia, has been studying certain stakes or piles, which were first pointed out to him nearly twenty years ago, by a fisherman, in the mud at the mouth of Naaman's Creek, a small tributary of the Delaware River. These piles are the first indication of anything in North America resembling the remains of lake-dwellings in Europe. Prof. F. W. Putnam, in his twenty-second Annual Report relating to the work of the Peabody Museum, says that Mr. Cresson's recent investigations led to the discovery of three distinct localities, near each other, which he designated Stations A, B, and C. Around these stations were found a very important and instructive collection of stone implements, a few points and fragments of bone, and a human tooth. At one station a number of fragments of rude pottery were found, and at this were obtained several pile-ends which are now in the Museum. This collection Mr. Cresson has given to the Museum, and he proposes soon to prepare a full account of his discoveries for publication. The Museum is also indebted to Mr. A. B. Huey, of Philadelphia, for a number of specimens which he obtained while with Mr. Cresson during the examination of Station B, and to Mr. W. R. Thompson, of Philadelphia, for several potsherds, and a large stone maul with a hole drilled through it, from the same station.

MR. A. E. BROWN, Superintendent of the Philadelphia Zoological Garden, says in his last Report that among the most valued additions to the collection of reptiles, during the past year, were five iguanas from the Isle of Pines, West Indies. These were at once seen to be different from any previously in the collection, and were subsequently identified by Prof. E. D. Cope as *Cyclura nubila*, Gray. The habit noticeable among the iguanas, of remaining fixed in one position when the attention is excited, or of "striking attitudes," is specially marked in these animals, and, several of them being of large size, they have attracted considerable attention. They are of an aggressive disposition, and cannot be readily handled, as they strike blows of astonishing force with their long tails, and bite with great tenacity any object with which they are disturbed. As with the better-known iguanas, their most suitable food in captivity appears to be bananas, hens' eggs, and milk.

IN the same Report, Mr. Brown says that the Philadelphia Zoological Society lately received, from the proprietor of a menagerie, a splendid male elephant called "Bolivar." The animal came originally from Ceylon, is now about thirty years old, stands nearly 10 feet in height at the shoulder, and weighs nearly 10,000 pounds. "It may well be doubted," says Mr. Brown, "if a finer specimen of his race has ever been included in a zoological collection."

MESSRS. BLACKIE AND SON have issued the second volume of their excellent "Modern Cyclopædia of Universal Information," edited by Dr. Charles Annandale. The present volume, if we may judge from the articles we have examined, is in all respects equal to the first, which we have already noticed.

WE have received from Tashkent an interesting Russian work, by A. Wilkins, on the culture of the American cotton-tree in Russian Turkestan. It appears that, though the first attempts at cultivating the *Gossypium hirsutum* in Central Asia proved unsuccessful, a new attempt, made since 1884, under the leadership of the Tashkent model farm, and with seeds taken from the continental States of America, has proved to be a real success. In 1887, there were no less than 38,700 acres under that crop in Turkestan, and in the following year the area was trebled. The crop of 1887 was estimated at 68,000 cwts. of raw cotton. Besides giving practical advice for the culture of the American cotton-tree, M. Wilkins's book contains valuable information about the climate of Turkestan, analyses of the soil and so on, from which it appears that, although the American species can be cultivated about Tashkent, where from 214 to 237 days every year are without frost, its real domain will be on the banks of the Zerafshan and the lower Amu-Daria, and in the Transcaspian region. It is also worthy of note that a new interesting variety of *Gossypium hirsutum*, differentiated by the fact that its flowers grow in groups of two, three, and four on a common stalk, has been obtained at the Tashkent model farm.

THE additions to the Zoological Society's Gardens during the past week include two Prairie Wolves (*Canis latrans* ♂ ♀) from the Rocky Mountains, presented by Mr. Charles Martin; two Long-fronted Gerbilles (*Gerbillus longifrons*) from Western Asia, presented by Lieut.-General Sir Harry B. Lumsden, K.C.S.I.; a Chattering Lory (*Lorius garrulus*) from Moluccas, presented by Mr. Thomas Taylor; two Slender-billed Cockatoos (*Licmetis tenuirostris*) from South Australia, two Goffin's Cockatoos (*Cacatua goffini*), habitat uncertain, presented by Dr. Seton; two Razorbills (*Alca torda*), British, presented by Dr. B. Hewetson; two Viperine Snakes (*Tropidonotus viperinus*), three Green Lizards (*Lacerta viridis*), two Marbled Newts (*Molge marmorata*), two Spotted Salamanders (*Salamandra maculosa*), two Edible Frogs (*Rana esculenta*), three Green Tree-Frogs (*Hyla arborea*) from Southern France, presented by the Rev. F. H. Holmes; a Smooth Snake (*Coronella lævis*) from Southern France, presented by Miss Agnes Flemyng; a Cocos-nut Crab (*Birgus latro* ♂) from India, presented by Commander Alfred Carpenter, R.N.; two Nicobar Pigeons (*Calœnas nicobarica* ♂ ♀) from the Indian Archipelago, a Collared Peccary (*Dicotyles tajaçu*) from South America, three Australian Waxbills (*Estrelda temporalis*) from Australia, purchased; three New Zealand Parakeets (*Cyanorhamphus novæ-zealandiæ*) from New Zealand, received in exchange; a Black Lemur (*Lemur macaco*), an Axis Deer (*Cervus axis* ♀), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

TWO REMARKABLE CONJUNCTIONS.—Mr. Marth called the attention of the Royal Astronomical Society at its last meeting, on June 14, to two remarkable conjunctions which will occur in the autumn of the present year, and which should be most carefully watched by astronomers the world over. The first is the conjunction of Mars and Saturn on September 20, at 20h. G.M.T., the closest conjunction of the two planets on record, the geocentric distance being only 54″, so that to the naked eye the two stars would probably appear to coalesce. The conjunction is rendered the more interesting from its occurring in the near neighbourhood of Regulus, which will be distant only 4′ of arc; whilst Venus passes over the same region of the sky three days later, passing within 12′ of Regulus. The conjunction of Mars with the Saturnian system on September 20 will be so close that it will have a very narrow escape of occulting Iapetus, the two being 12″ apart at 22h.

The second remarkable conjunction will be that of Iapetus, the outermost satellite of Saturn, with Titan. This will occur on November 1 at 8h., and the two satellites, moving in different directions, will pass within 3″ of each other. Shortly after this close approach Iapetus will enter the shadow of the ring system, and as Saturn is then near quadrature, the entire passage of the satellite through the shadow will be clear of the planet as seen from the earth. The satellite's path traverses the shadow of the rings on both sides of the planet, and the clear space between the planet and ring on one side, but probably not on both. It will be a matter of the greatest interest and importance to note if the satellite shines out when crossing the projection of the Cassinian division, and if it is at all visible when in the shadow of the dusky ring or crape veil. The Australian astronomers will have the opportunity, if weather serves, of observing this most rare and interesting occurrence, whilst those of America will be best able to observe the first-named conjunction, viz. that of Saturn and Mars.

The General Relations of the Phenomena of Variable Stars.—Under this title Mr. S. C. Chandler, who has in such an especial manner made the subject of variable stars his own, contributes to *Gould's Astronomical Journal*, No. 193, the results of his discussion of the facts as yet ascertained with relation to these objects. Making abstraction of the stars of the Algol time, it appears that variables may legitimately be divided into two great classes, those of short and those of long period; the former including the stars of less than 90 days' period, the latter those of more than 120 days. The first characteristic related to the length of period is that of colour—"the redder the tint, the longer the period." The range of variability is another feature. This also appears to depend upon the period—the greater the range, the longer the period—but the relation is not one of simple proportionality. The form of the light-curve is a third point. For the short-period variables the time of increase averages about two-thirds the time of decrease, but for the long-period stars the rate varies in a curious manner. Increase and decrease take about the same time for stars, between 100 and 200 days; then the ratio lessens, until for stars of about a year's period the time of increase is only about half that of increase; the ratio then increases again, and for the stars of longest period decline and recovery proceed with about equal speed. It is also noteworthy that though it would appear that stars with a period of a year or nearly a year are less likely to be readily discovered than those of a longer or shorter variation, yet as a matter of fact they form distinctly the most numerous class of the long-period stars. Both these curious facts stand as yet without explanation.

A point of difference between the long-period and short-period stars appears to be indicated in the irregularities to which their periods are severally subject; the irregularities in the first case being, broadly speaking, periodic in their nature, but in the second case secular, or at all events requiring very many cycles of the star for their development. These irregularities are common for the first class, but quite exceptional for the second. For these reasons, and considering the absence of stars of between 90 and 120 days, the difference in colour in average range of variation, and in form of light curve between the two classes, Mr. Chandler is led to believe that the cause of variation is probably different for the two classes of stars, as it is probably different again for the third class we call after Algol. With regard to the distribution of variables, Mr. Chandler shows that our present knowledge is insufficient to justify any very substantial inferences. A certain aggregation of short-period variables near the plane of the Milky Way does, however, seem to be indicated with some distinctness.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JUNE* 23–29.

(For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on June 23

Sun rises, 3h. 45m.; souths, 12h. 1m. 57·1s.; daily increase of southing, 12·9s.; sets, 20h. 19m.: right asc. on meridian, 6h. 9·3m.; decl. 23° 26′ N. Sidereal Time at Sunset, 14h. 28m.

Moon (New on June 28, 9h.) rises, 1h. 29m.; souths, 8h. 19m.; sets, 15h. 23m.: right asc. on meridian, 2h. 25·3m.; decl. 9° 21′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° ′
Mercury..	3 49 ...	11 36 ...	19 23 ...	5 43·6 ...	18 57 N.
Venus.....	1 41 ...	8 58 ...	16 15 ...	3 4·5 ...	13 56 N.
Mars......	3 33 ...	11 55 ...	20 17 ...	6 2·7 ...	24 11 N.
Jupiter....	20 16*...	0 10 ...	4 4 ...	18 15·8 ...	23 14 S.
Saturn....	7 41 ...	15 13 ...	22 45 ...	9 21·0 ...	16 42 N.
Uranus...	13 27 ...	18 58 ...	0 29*...	13 6·9 ...	6 26 S.
Neptune..	2 11 ...	9 59 ..	17 47 ...	4 5·7 ...	19 13 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

June.	h.	
24 ...	6 ...	Venus in conjunction with and 1° 0′ north of the Moon.
24 ...	19 ...	Jupiter in opposition to the Sun.
26 ...	7 ...	Venus at greatest distance from the Sun.
27 ...	8 ...	Mercury in conjunction with and 3° 4′ south of the Moon.
28 ...	3 ...	Mars in conjunction with and 1° 32′ north of the Moon.
28 ...	9 ...	Annular eclipse of the Sun: visible principally in the southern portions of Africa.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.
U Cephei ...	... 0 52·5 ...	81 17 N. ...	June 24,	22 27 *m*
			,, 29,	22 6 *m*
δ Libræ ...	... 14 55·1 ...	8 5 S. ...	,, 24,	20 50 *m*
U Coronæ ...	... 15 13·7 ...	32 3 N. ...	,, 26,	0 58 *m*
V Herculis ...	... 16 54·2 ...	35 14 N. ...	,, 26,	*M*
U Ophiuchi...	... 17 10·9 ...	1 20 N. ...	,, 27,	2 26 *m*
			,,	22 34 *m*
X Sagittarii...	... 17 40·6 ..	27 47 S. ...	,, 23,	22 0 *M*
			,, 28,	1 0 *m*
U Sagittarii...	... 18 25·6 ...	19 12 S. ...	,, 29,	1 0 *m*
β Lyræ... ...	... 18 46·0 ...	13 14 N. ...	,, 25,	22 0 *m*
			,, 29,	3 0 *M*
η Aquilæ ...	... 19 46·8 ...	0 43 N. ...	,, 25,	21 0 *m*
T Aquarii ...	... 20 44·1 ...	5 34 S. ..	,, 23,	*m*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near 52 Herculis ...	... 254 ...	47 N. ...	Swift.
,, δ Cygni... ...	... 295 ...	40 N. ...	Slow.
,, ε Delphini ...	... 305 ...	9 N. ...	June 28.

GEOGRAPHICAL NOTES.

The recent telegrams relative to Mr. Stanley's movements cannot be regarded as satisfactory. There can be no doubt that he has reached the east coast of the Victoria Nyanza, but that he could do so in eighty-seven days from Yambuya, on the Aruwimi, is incredible. Therefore the date, December 2, as that on which Mr. Stanley was at Ururi, on the south-east of Victoria Nyanza, must be wrong. Moreover a message would not take six months to reach Zanzibar from there; the journey in normal times can be done in one month. It is to be feared that Mr. Stanley has had to leave the problems connected with the Mwuta Nzigé unsolved. It would seem as if he had come round by the country to the north of Uganda, and so reached the Nyoro country on the north-east of Victoria Nyanza. After Emin received all the stores which Stanley took back with him (from Mslala on the south of Victoria Nyanza), the probability is that the Pasha would return to Wadelai. However, it is expected that a letter from Mr. Stanley will arrive in a few days.

Dr. Frithjof Nansen arrives in London to-morrow, and during his stay will be the guest of Prof. Flower.

The June number of the *Scottish Geographical Magazine* is a particularly good one. Mr. H. B. Guppy contributes the first part of the results of his observations on the Cocos-Keeling Islands, which promise to be an important addition to the already abundant literature on the formation of coral islands. Mr. Guppy also sends an interesting short paper on Tridacna pearls. Mr. W. B. Tripp's notes on South American rainfall south of the tropics are useful. Dr. H. R. Mill contributes a highly suggestive paper on scientific earth-knowledge as an aid to commerce. Dr. Mill really indicates the lines on which the scientific bases of commercial geography should be laid; and his paper, combined with what is being done elsewhere, leads us to hope that that hitherto ill-used and profitless subject may yet be worthy of a high place in technical education. In the same magazine is the report of an address by M. Kropotkin on the study of geography, which we commend to all interested in this important subject.

At the recent German Geographentag, Dr. Eschenhagen, of the Imperial Marine Observatory, described the results of his magnetic survey of the Harz Mountains, begun last autumn, and comprising about 3000 measurements. He has shown that no connection can be proved to exist between the ancient geological line of fracture of the Harz and the distribution of terrestrial magnetism, such as Naumann demonstrated in the case of Japan. Dr. Eschenhagen has extended his explorations in terrestrial magnetism over the whole of the north-west of Germany, so that, inasmuch as a similar survey of Austria-Hungary will be completed about 1892, our knowledge of the distribution of terrestrial magnetism in Central Europe has made a great advance.

Dr. O. Krummel contributes to the current number of *Petermann's Mitteilungen* an important paper on erosion through the agency of tidal currents, in which, by a careful examination of several specific instances, he endeavours to come to some conclusion as to the laws which govern the erosive work performed by the tides. There is paper of some practical importance on the suitability of Central Asia for Russian colonization, by General Annenkof.

The number of the *Boletino* of the Lisbon Geographical Society is entirely occupied by a long paper in French, by M. A. Marques, giving a detailed account of the Samoan Islands in all their aspects. As a summary of our knowledge of these islands, the paper will be found useful.

In the current number (4) of the *Mittheilungen* of the Vienna Geographical Society will be found the first part of a paper, by Herr Jankó, on the development and topography of the Rosetta mouth of the Nile.

Dr. Schweinfurth writes with great satisfaction of his journey in Hodeida, in Southern Arabia, in the early part of the present year. Among the places he visited were Khalife, at the foot of the Jebel Bura, Wolleje, the Jebel Melhān, Bajil, Hojela, Wossil, and Jebel Harrassa. The climate he found quite European, the nights bitterly cold, though it was hot enough for an hour or two in the middle of the day. Dr. Schweinfurth's botanical collections exceeded all his expectations; the mountain-slopes are covered with vegetation. He sent home some 600 species (1800 specimens), besides seeds and living plants.

In a very able memoir published by the Danish Society of Northern Antiquaries (in English), Prof. Gustav Storm rediscusses the vexed question of the Vinland voyages of the Norse colonists of Greenland, for the purpose of determining as accurately as the data will permit the various lands mentioned in the old Sagas. "Helluland," Prof. Storm is inclined to think, must be Labrador; Markland corresponds to Newfoundland, and Vinland to Cape Breton Island and Nova Scotia.

Mr. J. Y. Buchanan has been appointed Lecturer in Geography at the University of Cambridge.

It is reported from Sydney that the New South Wales branch of the Royal Geographical Society is sending an explorer, Mr. Arthur J. Vogan, to gather information relative to the far interior. Mr. Vogan will travel northwards from Fort Bourke to Pitchiri Creek, on the Upper Mulligan (lat. 21° S.), and after exploring the country from that point to the Herbert River, will either make his way to the Gulf of Carpentaria or to Hughenden. Mr. Vogan intended leaving Sydney during May.

ALUMINIUM.[1]

Chemists of many lands have contributed to our knowledge of the metal aluminium. Davy, in 1807, tried in vain to reduce alumina by means of the electric current. Oerstedt, the Dane, in 1824 pointed out that the metal could be obtained by treating the chloride with an alkali metal; this was accomplished in Germany by Wöhler in 1827, and more completely in 1845, whilst in 1854, Bunsen showed how the metal can be obtained by electrolysis. But it is to France, by the hands of Henri St. Claire Deville, in the same year, that the honour belongs of having first prepared aluminium in a state of purity, and of obtaining it on a scale which enabled its valuable properties to be recognized and made available, and the bar of "silver-white metal from clay," was one of the chemical wonders in the first Paris Exhibition of 1855. Now England and America step in, and I have this evening to relate the important changes which further investigation has effected in the metallurgy of aluminium. The process suggested by Oerstedt, carried out by Wöhler, and modified by Deville, remains in principle unchanged. The metal is prepared, as before, by a reduction of the double chloride of aluminium and sodium, by means of metallic sodium in presence of cryolite; and it is therefore not so much a description of a new reaction as of improvements of old ones of which I have to speak.

I may perhaps be allowed to remind my hearers that more than thirty-three years ago, Mr. Barlow, then secretary to the Institution, delivered a discourse, in the presence of M. Deville, on the properties and mode of preparation of aluminium, then a novelty. He stated that the metal was then sold at the rate of £3 per ounce, and the exhibition of a small ingot, cast in the laboratory by M. Deville, was considered remarkable. As indicating the progress since made, I may remark that the metal is now sold at 20*s*. per pound, and manufactured by the ton, by the Aluminium Company, at their works at Oldbury, near Birmingham. The improvements which have been made in this manufacture by the zeal and energy of Mr. Castner, an American metallurgist, are of so important a character, that the process may properly be termed the Deville-Castner process.

The production of aluminium previous to 1887, probably did not exceed 10,000 pounds per annum, whilst the price at that time was very high. To attain even this production required that at least 100,000 pounds of double chloride, and 40,000 of sodium should be manufactured annually. From these figures an idea of the magnitude of the undertaking assumed by the Aluminium Company may be estimated, when we learn that they erected works having an annually producing capacity of 100,000 pounds of aluminium. To accomplish this, required not only that at least 400,000 pounds of sodium, 800,000 of chlorine, and 1,000,000 of double chloride, should be annually manufactured, but in addition that each of these materials should be produced at a very low cost, in order to enable the metal to be sold at 20*s*. per pound.

The works, which now cover a space of nearly five acres, are divided into five separate departments, viz. (1) sodium; (2) chlorine; (3) chloride; (4) aluminium; and (5) foundry, rolling, wire mills, &c.

In each department an accurate account is kept of the production each day, the amount of material used, the different furnaces and apparatus in operation, &c. In this manner it has been found possible to ascertain each day exactly how the different processes are progressing, and what effect any modification has, either on cost, quantity, or quality of product. By this means a complicated chemical process is reduced to a series of very simple operations, so that whilst the processes are apparently complicated and difficult to carry out successfully, this is not the case now that the details connected with the manufacture have been perfected, and each operation carried on quite independently until the final materials are brought together for the production of the aluminium.

Manufacture of Sodium.

The first improvement occurs in the manufacture of sodium by what is known as the "Castner process." The successful working of this process marks an era in the production of sodium, as it not only has greatly cheapened the metal, but has enabled the manufacture to be carried out upon a very large scale with little or no danger. Practically, the process consists in heating fused caustic soda in contact with carbon whilst the former substance is in a perfectly liquid condition. By the process in vogue before the introduction of this method, it was always deemed necessary that special means should be taken to guard against actual fusion of the mixed charges, which, if it were to take place, would to a large extent allow the alkali and reducing material to separate. Thus, having an infusible charge to heat, requiring the employment of a very high temperature for its decomposition, the iron vessels must be of small circumference to allow the penetration of the heat to the centre of the charge without actually melting the vessel in which the materials are heated. By the new pro-

[1] The Friday evening discourse delivered by Sir Henry Roscoe, M.P., D.C.L., LL.D., V.P.R.S., at the Royal Institution of Great Britain, on May 3, 1889.

cess, owing to the alkali being in a fused or perfectly liquid condition in contact directly with carbon, the necessity of this is avoided, and consequently, the reduction can be carried on in large vessels at a comparatively low temperature. The reaction taking place may be expressed as follows:—

$$3NaHO + C = Na_2CO_3 + 3H + Na.$$

The vessels in which the charges of alkali and reducing material are heated are of egg-shaped pattern, about 18 inches in width at their widest part, and about 3 feet high, and are made in two portions, the lower one being actually in the form of a crucible, while the upper one is provided with an upright stem and a protruding hollow arm. This part of the apparatus is known as the cover. In commencing the operation, these covers are raised in the heated furnace through apertures provided in the floor of the heated chamber, and are then fastened in their place by an attachment adjusted to the stem; the hollow arm extends outside the furnace. Directly below each aperture in the bottom of the furnace are situated the hydraulic lifts, attached to the top of which are the platforms upon which are placed the crucibles to be raised into the furnace. Attached to the hydraulic lifts are the usual reversing valves for lowering or raising, and the platform is of such a size as, when raised, completely to fill the bottom aperture of the furnace. The charged crucible, being placed upon the platform, is raised into its position, the edges meeting those of the cover, forming an air-tight joint which prevents the escape of gas and vapour from the vessel during reduction, except by the hollow arm provided for this purpose. The natural expansion of the iron vessels is accommodated by the water-pressure in the hydraulic lifts, so that the joint of the cover and crucible are not disturbed until it is intended to lower the lift for the purpose of removing the crucible.

The length of time required for the first operation of reduction and distillation is about two hours. At the end of this time the crucibles are lowered, taken from the platforms by a large pair of tongs on wheels, carried to a dumping pit, and thrown on their side. The residue is cleaned out, and the hot pot, being again gripped by the tongs, is taken back to the furnace. On its way, the charge of alkali and reducing material is thrown in. It is again placed on the lift and raised in position against the edges of the cover. The time consumed in making the change is a minute and a half, and it only requires about seven minutes to draw, empty, recharge, and replace the five crucibles in each furnace. In this manner the crucibles retain the greater amount of their heat, so that the operation of reduction and distillation now only requires one hour and ten minutes. Each of the four furnaces, of five crucibles each, when in operation, are drawn alternately, so that the process is carried on night and day.

Attached to the protruding hollow arm from the cover are the condensers, which are of a peculiar pattern specially adapted to this process, being quite different from those formerly used. They are about 5 inches in diameter and nearly 3 feet long, and have a small opening in the bottom about 20 inches from the nozzle. The bottom of these condensers is so inclined that the metal condensed from the vapour issuing from the crucible during reduction, flows down and out into a small pot placed directly below this opening. The uncondensed gases escape from the condenser at the further end, and burn with the characteristic sodium flame. The condensers are also provided with a small hinged door at the further end, by means of which the workmen from time to time may look in to observe how the distillation is progressing. Previous to drawing the crucibles from the furnace for the purpose of emptying and recharging, the small pots each containing the distilled metal are removed, and empty ones substituted. Those removed each contain, on an average, about 6 pounds of metal, and are taken directly to the sodium casting shop, when it is melted and cast, either into large bars ready to be used for making aluminium, or in smaller sticks to be used.

Special care is taken to keep the temperature of the furnaces at about 1000° C., and the gas- and air-valves are carefully regulated, so as to maintain as even a temperature as possible. The covers remain in the furnace from Sunday night to Saturday afternoon, and the crucibles are kept in use until they are worn out, when new ones are substituted without interrupting the general running of the furnace. A furnace in operation requires 250 pounds of caustic soda every one hour and ten minutes, and yields, in the same time, 30 pounds of sodium and about 240 pounds of crude carbonate of soda. With the four furnaces at work, 120 pounds of sodium can be made every seventy minutes, or over a ton in the twenty-four hours. The residual carbonate, on treatment with lime in the usual manner, yields two-thirds of the original amount of caustic operated upon. The sodium, after being cast, is saturated with kerosene oil, and stored in large tanks holding several tons, placed in rooms specially designed both for security against either fire or water.

Chlorine Manufacture.

This part of the works is connected with the adjacent works of Messrs. Chance Bros. by a large gutta-percha pipe, by means of which, from time to time, hydrochloric acid is supplied direct into the large storage cisterns, from which it is used as desired for making the chlorine. For the preparation of the chlorine gas needed in making the chloride, the usual method is employed; that is, hydrochloric acid and manganese dioxide are heated together, when chlorine gas is evolved with effervescence, and is led away by earthenware and lead pipes to large lead-lined gasometers, where it is stored.

The materials for the generation of the chlorine are brought together in large tanks or stills, built up out of great sandstone slabs, having rubber joints, and the heating is effected by the injection of steam. The evolution of gas, at first rapid, becomes gradually slower, and at last stops; the hydrochloric acid and manganese dioxide being converted into chlorine and manganous chloride. This last compound remains dissolved in the "spent still liquor" and is reconverted into manganese dioxide, to be used over again, by Weldon's manganese recovery process. Owing to the difficulty of keeping up a regular supply of chlorine under a constant pressure directly from the stills, in order that the quantity passed into the sixty different retorts in which the double chloride is made can be regulated and fed as desired, four large gasometers were erected. Each of these is capable of holding 1000 cubic feet of gas, and is completely lined with lead, as are all the connecting mains, &c., this being the only available metal which withstands the corrosive action of chlorine. The gasometers are filled in turn from the stills, the chlorine consumed being taken direct from a gasometer under a regular pressure until it is exhausted; the valves being changed, the supply is taken from another holder, the emptied one being refilled from the still.

Manufacture of the Double Chloride.

Twelve large regenerative gas furnaces are used for heating, and in each of these are fixed five horizontal fire-clay retorts about 10 feet in length, into which the mixture for making the double chloride is placed. These furnaces have been built in two rows, six on a side, the clear passage-way down the centre of the building, which is about 250 feet long, being 50 feet in width. Above this central passage is the staging, carrying the large lead-mains for the supply of the chlorine coming from the gasometers. Opposite each retort, and attached to the main, are situated the regulating valves, connected with lead and earthenware pipes, for the regulation and passage of the chlorine to each retort. The valves are of peculiar design, and have been so constructed that the chlorine is made to pass through a certain depth of liquid, which not only, by opposing a certain pressure, allows a known quantity of gas to pass in a given time, but also prevents any return from the retort into the main, should an increase of pressure be suddenly developed in the retorts.

The mixture with which the retorts are charged is made by grinding together hydrate of alumina, salt, and charcoal. This mixture is then moistened with water, which partially dissolves the salt, and thrown into a pug mill of the usual type for making drain pipes, excepting that the mass is forced out into solid cylindrical lengths upon a platform alongside of which a workman is stationed with a large knife, by means of which the material is cut into lengths of about 3 inches each. These are then piled on top of the large furnaces to dry. In a few hours they have sufficiently hardened to allow of their being handled. They are then transferred to large waggons, and are ready to be used in charging the retorts.

The success of this process is in a great measure dependent—(1) on the proportionate mixture of materials; (2) on the temperature of the furnace; (3) on the quantity of chlorine introduced in a given time; and (4) on the actual construction of the retorts. I am, however, not at liberty to discuss the details of this part of the process, which have only a commercial interest. In carrying on the operation, the furnaces or retorts, when at the proper temperature, are charged by throwing in the balls until they are quite full, the fronts are then sealed up, and the charge allowed to remain undisturbed for about four hours, during which time the water of the alumina hydrate is completely expelled. At the end of this time the valves on the chlorine main are opened, and the gas is allowed to pass into the charged retorts. In the rear of each retort, and connected therewith by means of an earthenware pipe, are the condenser boxes, which are built in brick. These boxes are provided with openings or doors, and also with earthenware pipes, connected with a small flue for carrying off the uncondensed vapours to the large chimney. At first the chlorine passed into each retort is all absorbed by the charge, and only carbonic oxide escapes into the open boxes, where it burns. After a certain time, however, dense fumes are evolved, and the boxes are then closed, while the connecting pipe between the box and the small flue serves to carry off the uncondensed vapours to the chimney.

The reaction which takes place is as follows:—

$$Al_2O_3 + 2NaCl + 3C + 6Cl = 2AlCl_3NaCl + 3CO.$$

The chlorine is passed in for about seventy-two hours in varying quantity, the boxes at the back being opened from time to time by the workmen to ascertain the progress of the distillation. At the end of the time mentioned the chlorine valves are closed, and the boxes at the back of the furnace are all thrown open. The crude double chloride as distilled from the retorts, condenses in the connecting pipe and trickles down into the boxes, where it solidifies in large irregular masses. The yield from a bench of five retorts will average from 1600 to 1800 pounds, which is not far from the theoretical quantity. After the removal of the crude chloride from the condenser boxes the retorts are opened at their charging end, and the residue, which consists of a small quantity of alumina, charcoal, and salt, is raked out and remixed in certain proportions with fresh material, to be used over again. The furnace is immediately re-charged and the same operations repeated, so that from each furnace upwards of 3500 pounds of chloride are obtained weekly. With ten of the twelve furnaces always at work the plant is easily capable of producing 30,000 pounds of chloride per week, or 1,500,000 pounds per annum.

Owing to the presence of iron, both in the materials used (viz. charcoal, alumina, &c.) and in the fire-clay composing the retorts, the distilled chloride always contains a varying proportion of this metal in the form of ferrous and ferric chloride. When it is remembered that it requires 10 pounds of this chloride to produce 1 pound of aluminium by reduction, it will be quite apparent how materially a very small percentage of iron in the chloride will influence the quality of the resulting metal. I may say that, exercising the utmost care as to the purity of the alumina and the charcoal used, and after having the retorts made of special fire-clay containing only a very small percentage of iron, it was found almost impossible to produce upon a large scale a chloride containing less than 0·3 per cent of iron.

This crude double chloride, as it is now called at the works, is highly deliquescent, and varies in colour from a light yellow to a dark red. The variation in colour is not so much due to the varying percentage of iron contained as to the relative proportion of ferric or ferrous chlorides present, and although a sample may be either very dark or quite light, it may still contain only a small percentage of iron if it be present as ferric salt, or a very large percentage if it is in the ferrous condition. Even when exercising all possible precautions, the average analysis of the crude double chloride shows about 0·4 per cent. of iron. The metal subsequently made from this chloride therefore never contained much less than about 5 per cent. of iron, and, as this quantity great injures the capacity of aluminium for drawing into wire, rolling, &c., the metal thus obtained required to be refined. This was successfully accomplished by Mr. Castner and his able assistant, Mr. Cullen, and for some time all the metal made was refined, the iron being lowered to about 2 per cent.

The process, however, was difficult to carry out, and required careful manipulation, but as it then seemed the only remedy for effectively removing the iron, it was adopted and carried on for some time quite successfully, until another invention of Mr. Castner rendered it totally unnecessary. This consisted in purifying the double chloride before reduction. I cannot now explain this process, but I am able to show some of the product. This purified chloride, or pure double chloride, is, as you see, quite white, and is far less deliquescent than the crude, so that it is quite reasonable to infer that this most undesirable property is greatly due to the former presence of iron chlorides. I have seen large quantities containing upwards of 1½ per cent. of iron, or 150 pounds to 10,000 of the chloride, completely purified from iron in a few minutes, so that, whilst the substance before treatment was wholly unfit for the preparation of aluminium, owing to the presence of iron, the result was, like the sample exhibited, a mass containing only 1 pound of iron in 10,000, or 0·01 per cent. The process is extremely simple, and adds little or no appreciable cost to the final product. After treatment, this pure chloride is melted in large iron pots and run into drums similar to those used for storing caustic soda. As far as I am aware, it was generally believed to be an impossibility to remove the iron from anhydrous double chloride of aluminium and sodium, and few, if any, chemists have ever seen a pure white double chloride.

Aluminium Manufacture.

I now come to the final stage of the process, viz. the reduction of the pure double chloride by sodium. This is effected, not in a tube of Bohemian glass, as shown in Mr. Barlow's lecture in 1856, but in a large reverberatory furnace, having an inclined hearth about 6 feet square, the inclination being towards the front of the furnace, through which are several openings at different heights. The pure chloride is ground together with cryolite in about the proportions of two to one, and is then carried to a staging erected above the reducing furnace. The sodium, in large slabs or blocks, is run through a machine similar to an ordinary tobacco-cutting machine, where it is cut into small thin slices; it is then also transferred to the staging above the reducing furnace.

Both materials are now thrown into a large revolving drum, when they become thoroughly mixed. The drum being opened and partially turned, the contents drop out into a car on a tramway directly below. The furnace having been raised to the desired temperature, the dampers of the furnace are all closed to prevent the access of air, the heating gas also being shut off. The car is then moved out on the roof of the furnace until it stands directly over the centre of the hearth. The furnace roof is provided with large hoppers, and through these openings the charge is introduced as quickly as possible. The reaction takes place almost immediately, and the whole charge quickly liquefies. At the end of a certain time the heating gas is again introduced and the charge kept at a moderate temperature for about two hours. At the end of this period the furnace is tapped by driving a bar through the lower opening, which has previously been stopped with a fire-clay plug, and the liquid metal run out in a silver stream into moulds placed below the opening. When the metal has all been drawn off, the slag is allowed to run out into small iron waggons and removed. The openings being again plugged up, the furnace is ready for another charge. From each charge, composed of about 1200 pounds of pure chloride, 600 pounds of cryolite, and 350 pounds of sodium, about 115 to 120 pounds of aluminium are obtained.

The purity of the metal entirely depends upon the purity of the chloride used, and without exercising more than ordinary care the metal tests usually indicate a purity of metal above 99 per cent. On the table is the metal run from a single charge, its weight is 116 pounds, and its composition, as shown by analysis, is 99·2 aluminium, 0·3 silicon, and 0·5 iron. This I believe to be the largest and the purest mass of metal ever made in one operation.

The result of eight or nine charges are laid on one side, and then melted down in the furnace to make a uniform quality, the liquid metal, after a good stirring, being drawn off into moulds. These large ingots, weighing about 60 pounds each, are sent to the casting shop, there to be melted and cast into the ordinary pigs, or other shapes, as may be required for the making of tubes, sheets, or wire, or else used directly for making alloys of either copper or iron.

The following table shows approximately the quantity of each material used in the production of one ton of aluminium:—

Metallic sodium	6,300 pounds
Double chloride	22,400 ,,
Cryolite...	8,000 ,,
Coal	8 tons.

To produce 6,300 pounds of sodium is required:—

Caustic soda	44,000 pounds
Carbide, made from pitch, 12,000 pounds, and iron turnings, 1,000 pounds	7,000 ,,
Crucible castings	2½ tons
Coal	75

For the production of 22,400 pounds double chloride is required :—

Common salt	8,000 pounds
Alumina hydrate	11,000 ,,
Chlorine gas	15,000 ,,
Coal	180 tons.

For the production of 15,000 pounds of chlorine gas is required :—

Hydrochloric acid	180,000 pounds
Limestone dust...	45,000 ,,
Lime	30,000 ,,
Loss of manganese	1,000 ,,

[These figures were rendered more evident by the aid of small blocks, each cut a given size, so as to represent the relative weights of the different materials used to produce one unit of aluminium.]

It might seem, on looking over the above numbers, as if an extraordinary amount of waste occurred, and as if the production is far below that which ought to be obtained, but a study of the figures will show that this is not the case. I would wish to call attention to one item in particular, viz. fuel, it having been remarked that the consumption of coal must prevent cheap production. I think, when it is remembered that coal, such as is used at the works, costs only 4*s*. per ton, while the product is worth £2240 per ton, the cost of coal is not an item of consequence in the cost of production. The total cost of the coal to produce one ton of metal being £50, the actual cost for fuel is less than 6*d*. for every pound of aluminium produced. The ratio of cost of fuel to value of product is indeed less than is the case in making either iron or steel. In concluding my remarks as to the method of manufacture and the process in general, I do not think it is too much to expect, in view of the rapid strides already made, that, in the future, further improvements and modifications will enable aluminium to be produced and sold even at a lower price than appears at present possible.

Properties of Aluminium.

In its physical properties, aluminium widely differs from all the other metals. Its colour is a beautiful white, with a slight blue tint. The intensity of this colour becomes more apparent when the metal has been worked, or when it contains silicon or iron. The surface may be made to take a very high polish, when the blue tint of the metal becomes manifest, or it may be treated with caustic soda and then nitric acid, which will leave the metal quite white. The extensibility or malleability of aluminium is very high, ranking with gold and silver if the metal be of good quality. It may be beaten out into thin leaf quite as easily as either gold or silver, although it requires more careful annealing.

It is extremely ductile, and may be easily drawn, especial care only being required in the annealing.

The excessive sonorousness of aluminium is best shown by example [large suspended bar being struck]. Faraday has remarked, after experiments conducted in his laboratory, that the sound produced by an ingot of aluminium is not simple, and one may distinguish the two sounds by turning the vibrating ingot.

After being cast, it has about the hardness of pure silver, but may be sensibly hardened by hammering.

Its tensile strength varies between 12 and 14 tons to the inch [test sample which was shown having been broken at 13 tons or 27,000 pounds], ordinary cast iron being about 8 tons. Comparing the strength of aluminium in relation to its weight, it is equal to steel of 38 tons tensile strength. The specific gravity of cast aluminium is 2·58, but, after rolling or hammering, this figure is increased to about 2·68.

The specific gravity of aluminium being 1, copper is 3·6, nickel 3·5, silver 4, lead 4·8, gold 7·7.

The fusibility of aluminium has been variously stated as being between that of zinc and silver, or between 600° and 1000° C.

As no reliable information has ever been made public on this subject, my friend Prof. Carnelley undertook to determine it. I was aware, from information gained at the works at Oldbury, that a small increase in the percentage of contained iron materially raised its point of fusion, and it has been undoubtedly due to this cause that such wide limits are given for the melting-point. Under these circumstances two samples were forwarded for testing, of which No. 1, containing $\frac{1}{2}$ per cent. of iron, had a melting-point of 700° C. No. 2, containing 5 per cent. of iron, does not melt at 700°, and only softens somewhat above that temperature, but undergoes incipient fusion at 730°.

According to Faraday, aluminium ranks very high among metallic conductors of heat and electricity, and he found that it conducted heat better than either silver or copper. The specific heat is also very high, which accounts for length of time required for an ingot of the metal to either melt or get cold after being cast.

Chemically, its properties are well worthy of study.

Air, either wet or dry, has absolutely no effect on aluminium at the ordinary temperature, but this property is only possessed by a very pure quality of metal, and the pure metal in mass undergoes only slight oxidation even at the melting-point of platinum.

Thin leaf, however, when heated in a current of oxygen, burns with a brilliant, bluish-white light. [Experiment shown.] If the metal be pure, water has no effect on it whatever, even at a red-heat. Sulphur and its compounds also are without action on it, while, under the same circumstances, nearly all metals would be discoloured with great rapidity. [Experiment shown using silver and aluminium under the same conditions.]

Dilute sulphuric acid and nitric acid, both diluted and concentrated, have no effect on it, although it may be dissolved in either hydrochloric acid or caustic alkali. Heating in an atmosphere of chlorine it burns with a vivid light, producing aluminium chloride. [Experiment shown.] In connection with the subject it may be of interest to state the true melting-point of the double chloride of aluminium and sodium, which has always been given at 170° to 180° C., but which Mr. Baker, the chemist to the works, finds lies between 125° and 130° C.

Uses of Aluminium.

Its uses, unalloyed, have heretofore been greatly restricted. This is, I believe, alone owing to its former high price, for no metal possessing the properties of aluminium could help coming into larger use if its cost were moderate. Much has been said as to the impossibility of soldering it being against its popular use, but I believe that this difficulty will now soon be overcome. The following are a few of the purposes to which it is at present put: telescope tubes, marine glasses, eye-glasses and sextants, especially on account of its lightness; fine wire for the making of lace, embroidery, &c; leaf in the place of silver leaf, sabre sheaths, sword handles, &c., statuettes and works of art, jewellery and delicate physical apparatus, culinary utensils, harness fittings, metallic parts of soldiers' uniforms, dental purposes, surgical instruments, reflectors (it not being tarnished by the products of combustion), photographic apparatus, aëronautical and engineering purposes, and especially for the making of alloys.

Alloys of Aluminium.

The most important alloys of aluminium are those made with copper. These alloys were first prepared by Dr. Percy, in England, and now give promise of being largely used. The alloy produced by the addition of 10 per cent. of aluminium to copper, the maximum amount that can be used to produce a satisfactory alloy, is known as aluminium bronze. Bronzes, however, are made which contain smaller amounts of aluminium, possessing in a degree the valuable properties of the 10 per cent. bronze. According to the percentage of aluminium up to 10 per cent., the colour varies from red gold to pale yellow. The 10 per cent. alloy takes a fine polish, and has the colour of jeweller's gold. The 5 per cent. alloy is not quite so hard, the colour being very similar to that of pure gold. I am indebted to Prof. Roberts Austen for a mould in which the gold at the mint is usually cast, and in this I have had prepared ingots of the 10 and 5 per cent. alloy, so that a comparison may be made of the colour of these with a gold ingot cast in the same mould, for the loan of which I have to thank Messrs. Johnson, Matthey, and Co., all of which are before you.

I have also ingots of the same size, of pure aluminium, from which an idea of the relative weights of gold and aluminium may be obtained.

To arrive at perfection in the making of these alloys, not only is it required that the aluminium used should be of good quality, but also that the copper must be of the very best obtainable. For this purpose only the best brands of Lake Superior copper should be used. Inferior brands of copper or any impurities in the alloy give poor results. The alloys all possess a good colour, polish well, keep their colour far better than all other copper alloys, are extremely malleable and ductile, can be worked either hot or cold, easily engraved, the higher grades have an elasticity exceeding steel, are easily cast into complicated objects, do not lose in remelting, and are possessed of great strength, dependent, of course, on the purity and percentage of contained aluminium. The 10 per cent. alloy, when cast, has a tensile strength of between 70,000 and 80,000 pounds per square inch, but when hammered or worked, the test exceeds 100,000 pounds. [A sample shown broke at 105,000 pounds.]

An attempt to enumerate either the present uses or the possible future commercial value of these alloys is beyond my present purpose. I may, however, remark that they are not only adapted to take the place of bronze, brass, and steel, but they so far surpass all of those metals, both physically and chemically, as to make their extended use assured. [Sheets, rods, tubes, wire, and ingots shown.]

But even a more important use of aluminium seems to be its employment in the iron industry, of which it promises shortly to become an important factor, owing to certain effects which it produces when present, even in the most minute proportions. Experiments are now being carried on at numerous iron and steel works, in England, on the Continent, and in America. The results so far attained are greatly at variance, for whilst in the majority of cases the improvements made have encouraged the continuance of the trials, in others the result has not been satisfactory. On this point I would wish to say to those who may contemplate making use of aluminium in this direction, that it would be advisable before trying their experiments to ascertain whether the aluminium alloy they may purchase actually contains any aluminium at all, for some of the so-called aluminium alloys contain little or no aluminium, and this may doubtless account for the negative results obtained. Again, others contain such varying proportions of carbon, silicon, and other impurities, as to render their use highly objectionable.

It seems to be a prevailing idea with some people, that, because aluminium is so light compared with iron, they cannot be directly alloyed, and, furthermore, that, for the same reason, alloys made by the direct melting together of the two metals would not be equal to an alloy where both metals are reduced together. Now, of course, this is not the case, and the statement has been put forward by those who were only able to make the alloys in one way.

Aluminium added to molten iron and steel lowers their melting-points, consequently increases the fluidity of the metal, and causes it to run easily into moulds and set there, without entrapping air and other gases, which serve to form blow-holes and similar imperfections. It is already used by a large number of steel founders, and seems to render the production of sound steel castings more certain and easy than is otherwise possible.

One of the most remarkable applications of the property which aluminium possesses of lowering the melting-point of iron has been made use of by Mr. Nordenfeldt in the production of castings of wrought iron.

Aluminium forms alloys with most other metals, and although each possesses peculiar properties which in the future may be utilized, at present they are but little used.

In conclusion, I beg to call your attention to the wood models on the table, one being representative of aluminium, the other aluminium bronze. The originals of these models are now in the Paris Exhibition, each weighing 1000 pounds. With regard to aluminium bronze, I cannot speak positively, but the block of pure aluminium is undoubtedly the largest casting ever made in this most wonderful metal. I have to thank the Directors of the Aluminium Company, and especially Mr. Castner, for furnishing me with the interesting series of specimens of raw and manufactured metal for illustrating my discourse.

THE PALÆONTOLOGY OF STURGEONS.[1]

THE palæontological history of the Acipenseroid fishes is at present very imperfectly known. In the existing fauna, only two families are recognizable—that of the Acipenseridæ, with series of bony dermal scutes upon the trunk, and that of Polyodontidæ, destitute of any such armour; both these occupy so low a position in the scale of organization, that considerable evidence of numerous extinct allies might naturally be expected to occur among the fossils of the older rocks. Such evidence, however, can as yet be only slightly recognized. Remains of typical members of the two existing families seem to occur as low in the Tertiary series as the Eocene formation. Pectoral spines and dermal scutes, indistinguishable from those of the living *Acipenser*, are met with in the Upper Eocene of the Hampshire Basin, and the London Clay (Lower Eocene) of the Isle of Sheppey; and Prof. E. D. Cope has described a fish (*Crossopholis*) from the Eocene Green River Shales of Wyoming, U.S.A., differing only from the typical Polyodontidæ in the possession of rudimentary scales upon the sides of the trunk.

The only Cretaceous fossils yet known, which are at all comparable with characteristic parts of the Acipenseroid skeleton, are two specimens from the English Chalk. The remains of a tail from Gravesend, in the British Museum, are most satisfactorily interpreted as belonging to a fish of this type; and the extremity of a snout from Sussex, in the Willett Collection, Brighton, seems to be more nearly paralleled by the snout of *Acipenser* than by that of any other known fish. Other fragmentary evidence of Acipenseroids in Upper Jurassic rocks will probably soon be recognized, thanks especially to the investigations of Mr. Alfred N. Leeds in the Oxford Clay of Peterborough; but the most complete and unmistakable fossils occur in the English Lower Jurassic—both in the Upper Lias of Whitby and the Lower Lias of Lyme Regis.

The gigantic Acipenseroid of Whitby was first noticed by Agassiz, under the name of *Gyrosteus mirabilis*, but it has not hitherto been scientifically investigated and described. The head seems to have been enveloped in few membrane bones, none externally ornamented or covered with ganoine; the chondrocranium is scarcely ossified; and the jaws are toothless. The opercular apparatus is incomplete, without branchiostegal rays; and the membrane bones of the pectoral arch are unornamented. There is evidence of a persistent notochord, and a few ossified ribs occur anteriorly. The upper lobe of the tail exhibits the characteristic series of large fulcra, and the trunk seems to have been naked.

Gyrosteus thus conforms to the normal Acipenseroid type as represented at the present day; but the genus of the Lower Lias, *Chondrosteus*, displays many striking differences. As pointed out especially by Dr. R. H. Traquair, these differences tend to place the fish half-way between the modern Sturgeons and the typically Palæozoic group of Palæoniscidæ. The roof of the skull exhibits definite frontal, parietal, squamosal, and supra-temporal membrane bones; in addition to the operculum and sub-operculum there are distinct branchiostegal rays; and in minor features there are several interesting resemblances to points of Palæoniscid osteology. Dr. Traquair, indeed, places the Palæoniscidæ in the "Acipenseroidei"; and it may be that, as no typical Acipenseroids of corresponding antiquity are known, the Sturgeons and Polyodons are the somewhat degenerate descendants of Palæozoic fishes upon this biological level. At the same time, it must be remembered that the Palæoniscidæ pass by several known gradations into the characteristic bony Ganoids of Mesozoic age; and if the ascertained facts of palæichthyology are already a sufficient basis for phylogenetic speculation, it thus appears that two diverging series arise from this primitive stock. In his latest classification (*American Naturalist*, 1887, p. 1018), Prof. Cope admits the origin of the later Ganoids from fishes of a Palæoniscid type; but, on the assumption that the basal cartilages (baseosts) of the pelvic fin in Palæoniscidæ were minute or absent, the Sturgeons are placed lower in the series than the latter. Under any circumstances, the relative development of a single structural feature is a slight point for the distinction of two "superorders"; and if "Podopterygia" and "Actinopterygia" are to hold separate rank, the Palæoniscidæ (so far as all positive evidence is concerned) may be as justly placed in the former as in the latter.

[1] Abstract of a Paper, by A. Smith Woodward, read before the Geologists' Association on January 4.

NITRATE OF SODA, AND THE NITRATE COUNTRY.

I.

TILL lately, nitrate of soda has only been known to the few who dealt in manures, or who were engaged in chemical manufactures; but within the last two years the British public have invested vast sums of money in the shares of Nitrate Companies, while the presence in society of live millionaires who have made their money in Tarapaca, and the strong personality of a "Nitrate King," have made "nitrates" a household word.

Deposits of nitrate of soda are known along the west coast of South America for a distance of 500 miles at least, from a little south of Taltal up to the River Camerones; and it is reported that beds have been discovered 150 miles further north, in the province of Arequipa (see Fig. 1).

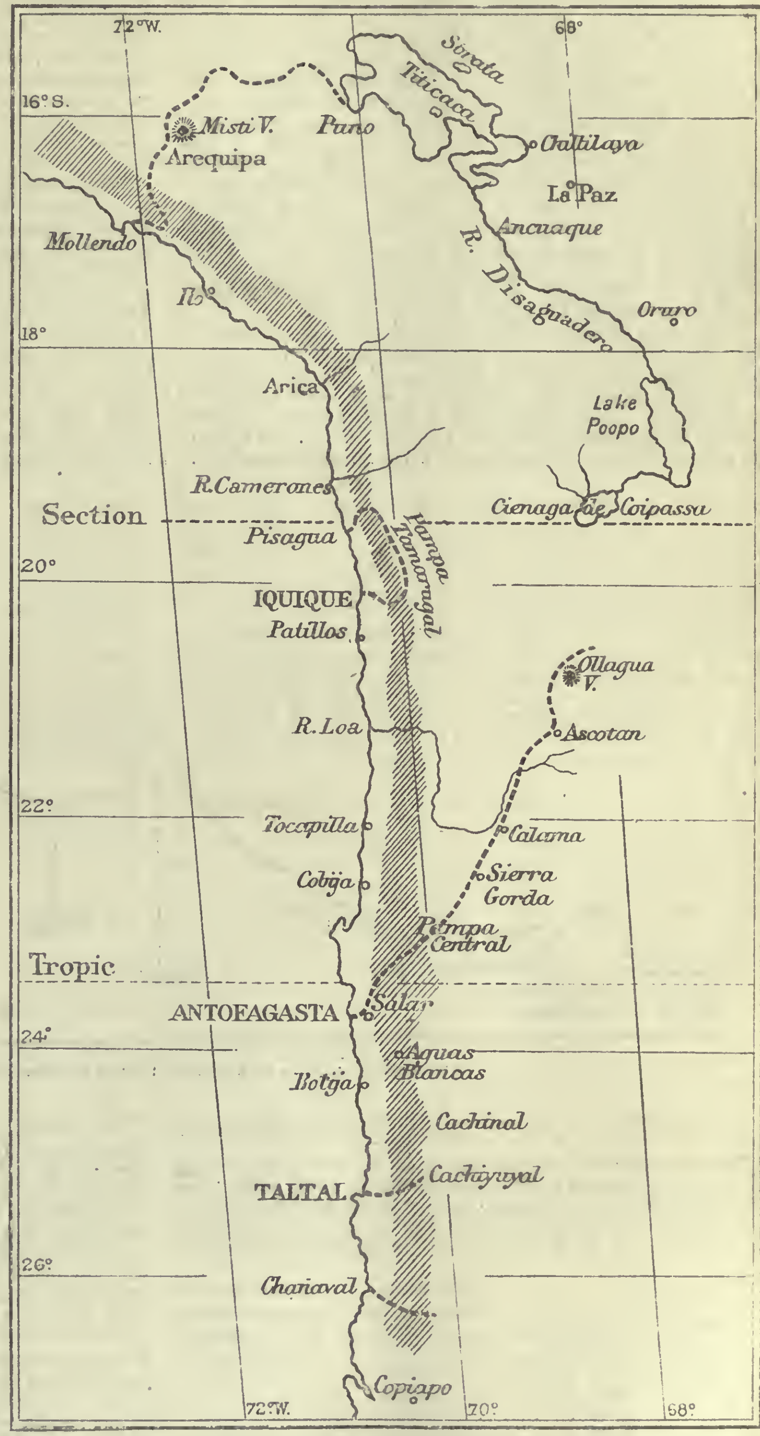


Fig. 1.—Map of the nitrate districts of South America. The shaded parts are nitrate grounds; but those north of the River Camerones are uncertain.

The physical structure of the coast is identical throughout all that great length. Everywhere an arid range of hills 4000–6000 feet high rises abruptly out of the sea; while, behind them, a flat, waterless desert Pampa slopes gradually up for 50–100 miles to the foot of the snowy Cordillera. Nitrates are only found on this desert Pampa, but under somewhat variable conditions. On the Tamarugal Pampa—where all the great English companies have their factories—the nitrate is found exclusively on the western or seaward edge of the Pampa, on the first slopes of the coast-range; in the Noria district, on the lowest portion of a district surrounded by hills; and above Antofagasta on the sides of a dry river-bed.

The aspect of the Pampa is always essentially of the desert type. Above Iquique, the plain is sparsely covered with Tamarugal bushes; and the bold features of the Cordillera above Tarapaca form a sufficiently pleasing landscape. Inside from Antofagasta, on the desert of Atacama, there is no view of the mountains, and nothing greets the eye but a sloping plain of brown earthy sand, whose distant outlines can scarcely be distinguished through the quivering air. No cloud on the sky tempers the rays of a nearly vertical sun, blue mirage lakes tantalize the thirsty traveller, the hand can scarcely touch the scorching sand at 130°, the parched air may indicate 90°, and a light south-west wind raises whirlwinds of dust in every direction. Not a bird, nor a beast, nor a plant of the lowest type can live on these barren wastes; and yet the hidden wealth below has led to the erection of villages which contain more than 500 people, whose every necessary of life has to be brought from a great distance.

The absence of water has always been a great difficulty in the way of carrying on any industry in these deserts. Fifteen years ago, water sold on the Atacama desert for $20 the *arroba*—say 10*s*. a gallon—and a drink for a mule cost 15*s*. At Carmen Alto, in the same district, a sun condenser, with 50,000 square feet of glass, was employed to distil fresh from salt water; and though this was afterwards wrecked by a whirlwind, a smaller apparatus, on the same principle, is now working at a profit at Sierra Gorda, though the water is sold at only 30 cents. the *arroba*, or about $1\frac{1}{2}$*d*. a gallon.

Fresh water is now supplied to most of the towns on the coast, and to the factories inland, by means of condensed steam. Some of the condensers can produce no less than 25 tons of good water for every ton of coal burnt in the boilers; and some are even reported to have attained an efficiency of 30 tons of water for the same amount of fuel.

More recently, schemes have been started for the water supply of the towns on the coast by pipes from springs at the foot of the mountains beyond the Pampa; and Mollendo, Iquique, Antofagasta, and Taltal are either actually supplied with drinking-water by this means, or works are in progress for the same purpose.

Very few Indians can have lived on the Pampa before the arrival of Europeans. A few Changos still survive along the seaward face of the coast range, who live by fishing, and who till recently had no knowledge of metals. The Aymara language is still spoken in Tarapaca, and all the place-names on the Tamarugal Pampa—such as Paccha, Jaz Pampa, Puntunchara, &c.—belong to that idiom. In the Antofagasta and Taltal districts, on the contrary, though further to the south, the place-names, such as Cachinal, &c., are Quichua, and any Indians of the Cordillera speak in that tongue. A good many of the *peons*, or labourers, who work in the *maquinas*, are Bolivians from Cochabamba, who talk Quichua, and some of the words used in the factories, such as *cancha*, &c., are derived from that language. These men chew *coca*, and though not so strong, are more laborious than the Chillenos from the south.

Passing from these generalities, we will now examine in more detail the structure and climate of the Tamarugal Pampa, between Iquique and Pisagua, in which most English people are interested. Fig. 2 is a diagrammatic section from the sea across the Cordillera, through the nitrate beds of Tarapaca. To the left we see the barren coast range rising from the sea and falling again to the level of the Tamarugal Pampa. The nitrate beds are marked in their proper place at the first spring of the hill; then comes the level Pampa, sloping gently not only from the Cordillera, but also slightly in a south-west direction. This slope is of course enormously exaggerated in the diagram.

Next the counterforts of the Sierra of Huatacondo rise abruptly above the plain. Here and there the barren slopes of these mountains are intersected by narrow valleys or *quebradas*, each of which carries down a small stream of water that is eventually lost in the sand of the Pampa. Artificial irrigation at the side of each affords sustenance for a very scanty population, and only one village is of sufficient importance to form anything approaching to a small town. This is the town of Tarapaca, in a valley of the same name, which gives its name to the province in which Iquique and the nitrate beds are situated.

A high cold upland, or Puna, some 20 miles across, separates the crests of the outer Sierra of Huatacondo from the rather higher range of the Cordillera Silillica, and then the mountains slope steeply down to the plateau of Bolivia, some 12,000 feet above the sea. None of the crests of the outer Sierra retain any snow on their summits during the summer months, but a few of the crests of the inner Cordillera are white throughout the year.

Allusion has been already made to the Tamarugal bushes which are found in places on the Pampa. These owe their existence to the floods, or *avenidas* as they are called locally, which every few years rush down from the Sierra, and run over the plain almost to the edge of the nitrate grounds. The soil of the Pampa is just what might have been expected under such circumstances, for the surface is not sharp sand, but really dry earth with a certain proportion of sandy particles, and only irrigation is required to turn the desert Pampa into a fertile plain. Below ground, numerous sections which have been made in sinking wells, show alternating layers of gravel, sand, mud, and as each series of layers represents the sequence of a single flood, it follows that the Pampa has been subject to periodical inundations for a very long period.

The labours of Signor Don Guillermo Billinghurst have made us acquainted both with the *régime* of underground waters on the Pampa, and with their chemical constitution. From his researches it appears that water is found almost anywhere under the Pampa, at depths varying from about 50 to 150 feet, but that nowhere are the conditions necessary for artesian wells fulfilled. The well water from the centre of the Pampa contains too great a proportion of salts to be considered drinkable; and that from the western margin of the plain, but not in the nitrate beds, belongs to the calcareo-magnesian class, which is totally unfit for domestic or culinary purposes. The following examples will make this very clear, and also the remarkable fact that *the underground waters of the Pampa do not contain the slightest trace either of nitrate of soda, or of iodine*, though they contain a greater proportion of mineral salts the further westward they run.

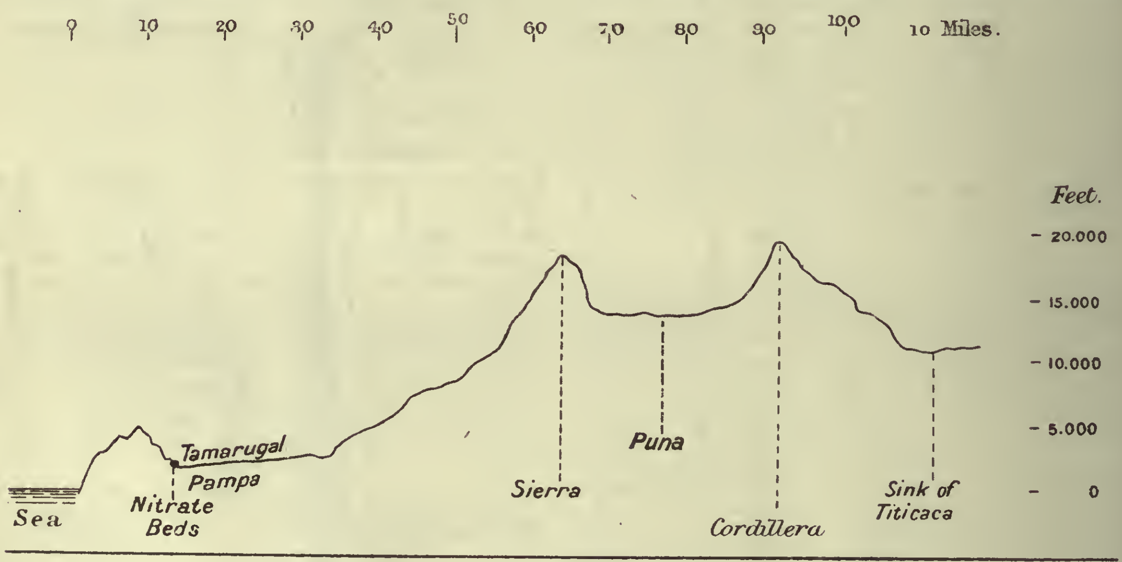


FIG. 2.—Section across the Cordillera, through the nitrate beds of Tarapaca.

The two subjoined analyses are those (1) of well water from Cerro Gordo, situated 7 miles from the nitrate beds, on the open plain of the Tamarugal Pampa; and (2) of the Pozo de Almonte, quite close to the nitrate beds, and from which a large proportion of the water used by the Nitrate Railway Company is derived—

	Cerro Gordo. Grammes per litre.	Pozo de Almonte. Grammes per litre.
Carbonate of lime	0·01500 ...	0·2499
,, magnesia ...	0·00300 ...	0·0323
Sulphate of lime	0·12920 ...	0·9843
,, magnesia	0·08166 ...	—
,, potash	0·00860 ...	—
,, soda	0·18062 ...	0·0735
Chloride of sodium	0·62261 ...	1·5799
,, magnesium	— ...	0·1737
Oxide of iron and alumina ...	0·01000 ...	—
Silica, and insolubles	0·00500 ...	0·0200
	1·05569	3·1136

In connection with underground waters we may as well dispel for ever the fiction so commonly believed that some of the overflow from Lake Titicaca filters under the Cordillera and reappears on the Tamarugal Pampa. This idea was started in a pre-scientific age, more than 300 years ago, in 1550, by the celebrated historian Cieza de Leon ("La Cronica del Peru," p. 445); but unfortunately for such a supposition the facts of the case are as follows. The only outlet of Lake Titicaca is the River Disaguadero (Span. drain), and the water at starting contains about 1 gramme of salts in every litre. By the time the river has reached the shallow lake of Poopo or Aullagas (see map, Fig. 1), the water is so salt as to be undrinkable, and then the river runs out for a short distance till it is finally lost in the salt mud marsh, or Ciénaga de Coipasa. No doubt this marsh is due east of the Pampa near Pisagua, and is marked "Sink of Titicaca" in Fig. 1; but still it is impossible to believe that salt water can come out fresh on the other side of the Cordillera. The water of the Tamarugal Pampa must be derived from the rainfall on the slopes of the Sierra, immediately above the plain.

RALPH ABERCROMBY.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—The Savilian Professor of Geometry, J. J. Sylvester, will deliver, early next term, a public lecture on the sufficiency of Barbier's principle to furnish a universal and geometrical solution of a celebrated problem of chances originated by Buffon, but whose solution of it, and also that of Laplace, was limited to the two simplest cases, and involved the use of the integral calculus. The lecture will be divested as far as possible of technical terms, so as to be made intelligible to a general audience. Time and place will be stated in a subsequent notice.

Cambridge.—In the Natural Sciences Tripos, Part I., lately issued, the following men are placed in Class I.:—Beddard, Trinity; Blackman, St. John's; Bottomley, Caius; Cole, Christ's; de Havilland, Peterhouse; L. G. Glover, St. John's; Hewitt, St. John's; Lehfeldt, St. John's; Luce, Christ's; Peters, Caius; Reynolds, Trinity; Rolleston, King's; Spivey, Trinity; Thomas, Sidney; Wood, Caius; Woods, St. John's. The following women also obtained a first class:—A. I. M. Elliot, Newnham; L. Martin-Leake, Girton; M. O. Mitchell, Newnham.

In the Natural Sciences Tripos, Part II. (advanced), eleven candidates are placed in Class I. Of these no fewer than six are scholars of St. John's College, including Mr. Horton-Smith, who receives the coveted mark of distinction in Physiology. No mark of distinction has been granted since 1883. The following are the names, in alphabetical order:—Baily, St. John's (Physics); d'Albuquerque, St. John's (Chemistry); Ds Daniel, Trinity (Human Anatomy with Physiology); S. F. Dufton, Trinity (Chemistry); Elliott, Christ's (Chemistry); Groom, St. John's (Geology); Hankin, St. John's (Physiology); Horton-Smith, St. John's (Physiology and Human Anatomy with Physiology); Locke, St. John's (Physiology); Ds Tennant, Caius (Chemistry); Whetham, Trinity (Physics). No women obtained a first class in this part.

Dr. W. H. Gaskell, F.R.S., has been elected Fellow and Prælector in Natural Science of Trinity Hall. This long-deferred recognition of Dr. Gaskell's eminent services to the teaching of physiology at Cambridge, and also of his many valuable original researches, will be welcomed by all scientific men.

The General Board of Studies recommends that the stipend of Dr. Gaskell, as University Lecturer in Physiology, be raised from £50 to £150 per annum, and that of Mr. Walter Gardiner, University Lecturer in Botany, from £50 to £100. Both these gentlemen hold College Fellowships in addition.

Mr. E. G. Gallop, late Fellow of Trinity College, and Senior Wrangler, has been elected to a Fellowship at Gonville and Caius College.

At the annual election at St. John's College on June 17 the following awards were made in Mathematics and Natural Science:—

Hutchinson Studentship (for research in Physiology): Horton-Smith.

Foundation Scholarships (continued or increased): Mathematics—Flux, R. A. Sampson, Rudd, Lawrenson, Cooke, Monro, Burstall, G. T. Bennett, Dobbs, Reeves, Gedye. Natural Science—Groom, d'Albuquerque, Locke, Hankin, Baily, Horton-Smith, Hewitt.

Foundation Scholarships (awarded): Mathematics—W. Brown, Alexander, Finn. Natural Science—Lehfeldt, Woods.

Exhibitions: Mathematics—Bennett, Finn, Reeves, Ayers, Blomfield, Maw, O. W. Owen, Schmitz, Speight, Wills. Natural Science—Baily, Lehfeldt, Locke, Blackman, Cuff, L. G. Glover, MacBride.

Proper Sizarships: Mathematics—Ayers, Maw, Pickford, C. Robertson.

Wright's Prizes: Mathematics—Bennett. Natural Science—Horton-Smith, Hewitt, MacBride.

Hockin Prize (for Physics): Baily.

Herschel Prize (for Astronomy): Monro, *proxime accessit* Bruton.

Hughes Prize (for best student of third year): Natural Science—Horton-Smith.

SCIENTIFIC SERIALS.

American Journal of Science, June.—Topographical development of the Triassic formation of the Connecticut Valley, by William Morris Davis. In this paper are embodied the results of two visits paid to the region about Meriden with the Harvard Summer School of Geology in 1887 and 1888. After describing the topographical development of the Triassic belt, the author shows that the whole region was base-leveled in late Cretaceous times, and the present valleys worn in the Cretaceous base-level plain after its elevation. The Connecticut River was originally consequent on the monoclinal faulting, and still persists near the course then taken, but has entered a second cycle of life as a result of the elevation of the lowland that was produced in its first cycle.—Analyses of three descloizites from new localities, by W. F. Hillebrand. The specimens, of which full analyses are here given, came from the mines of Beaverhead County, Montana; Grant County, New Mexico; and Cochise County, Arizona. It is suggested that, in view of the well-defined character of all these highly cupriferous varieties, they might be appropriately designated by some common distinctive name, such as Rammelsberg's cupro-descloizite, as indicating the relationship to descloizite.—A new meteorite from Mexico, by J. Edward Whitfield. This specimen of meteoric iron, weighing 33 kilos, came originally from the Sierra de San Francisco in the State of Durango, date of discovery and name of finder being unknown. Analysis shows iron 91·48, nickel 7·92, cobalt 0·22, with traces of sulphur and carbon. Slices when etched show rather coarse Widmanstättian figures with dark diagonal bands of triolite.—Contributions to the petrography of the Sandwich Islands, by Edward S. Dana. The eruptive rocks here described were partly obtained in 1887 by Prof. J. D. Dana, and partly in 1888 by the Rev. E. P. Baker, of Hilo. They include about thirty specimens from Kilauea, a dozen from the island of Maui, and a like number from the island of Oahu. The chief points brought out by their study are the characters of the clinkstone-like basalt with its novel forms of feather-augite, and also of the heavy chrysolitic basalt, both from the summit crater. The lavas from Maui and Oahu belong mostly to the basaltic type, though often resembling andesite in appearance.—The determination of water and carbonic acid in natural and artificial salts, by Thomas M. Chatard. An apparatus is described, which has been successfully used for the analysis of a large number of natural and artificial alkaline carbonates, giving results satisfactory both for accuracy and the ease and rapidity with which they were obtained. The method is in every way superior to the distillation process, and promises to be of value for technical purposes.—Preliminary note on the absorption spectra of mixed liquids, by Arthur E. Bostwick. The experiments here described were undertaken to determine the true character of the absorption spectra of mixed liquids, which, according to Prof. Melde, are not formed by simple addition of the component spectra, but by the shifting of the bands, a large band of one liquid seeming to attract a small band of the other, and more strongly as the proportion of the former in the mixture is increased. On the other hand, Dr. Shuster held that where a small band falls on the slope of a large one the effect of optical addition is to shift the apparent maximum of absorption. But Mr. Bostwick's experiments apppear to prove that, while a small part may be due to the cause alleged by Dr. Shuster, the bands are shifted principally by a true action of one liquid on the other.—Notes on metallic spectra, by C. C. Hutchins. An attempt is here made to determine the wave-length of several metallic lines with something of the precision with which wave-lengths of solar lines are known and tabulated.—On allotropic forms of silver, by M. Carey Lea. By means of a new reaction (the reduction of silver citrate by ferrous citrate) the author has obtained three remarkable forms of allotropic silver, the properties and physical condition of which are here described in detail.

In the *American Meteorological Journal* for April, Prof. Abbe contributes an article on the red sunsets of 1884–85, which is of interest from the fact of its having been written before the publication of the Krakatão Report of the Royal Society Committee relating to the glows of the previous year. The author considers that in the production of the glows, vapour haze is more important than dust haze, and that the Krakatão eruption sufficed to throw enough moisture into the atmosphere to explain the diffraction phenomena of 1883–84, without the hypothesis of the accumulation of the vapour of meteoric dust.—Lieut. Finley gives a chart and list of the tornadoes in the State of Missouri during the 75 years ending 1888. The total number of storms was 169, the month of greatest frequency was May, and none occurred in January.—Prof. Marvin contributes an interesting article on the measurement of wind velocity, and the results of recent anemometrical experiments by the Signal Service. He points out that if the equation of an anemometer, whose constants have been determined by a whirling machine, be used to reduce observations made in the open air, the computed wind velocities will be too high, by an amount which will depend upon the moment of inertia of the cups and revolving parts. Some of the experiments described were of a delicate nature, the cups being made of paper fastened to pieces of fine knitting-needles, which served as arms.—The concluding article is by Prof. R. Owen, on magnetic phenomena in the southern hemisphere, the object being to give some particulars regarding the experiments made in that hemisphere, as compared with results obtained in the northern half of the globe.

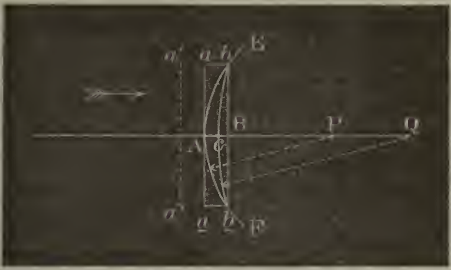
SOCIETIES AND ACADEMIES.

London.

Royal Society, June 6.—"Report on the Effects of Contact Metamorphism exhibited by the Silurian Rocks near the Town of New Galloway, in the Southern Uplands of Scotland." By S. Allport and Prof. Bonney, F.R.S.

In the neighbourhood of New Galloway a mass of granite cuts across and sends veins into a series of Silurian rocks, which are considerably altered near the junction. These, originally, were a variable series of more or less sandy rocks, such as older authors would call greywacke. The minerals resulting from the "contact-metamorphism" were enumerated: these were quartz brown mica (which, as was pointed out, must be much richer in iron than in magnesia), white mica, and iron oxides, with some hornblende, augite, garnet, and perhaps epidote. Chiastolite is absent; andalusite very inconspicuous; tourmaline very rare The point to which special attention was directed was that in several of the slides, the larger fragments which had been present in the original greywacke could still be recognized, such as clastic quartz, feldspar (often more or less converted into white mica and quartz), bits of argillite or earthy sandstone (represented by mixtures of brown mica and quartz in varying proportions). The bearing of the results of the investigation on general questions of metamorphism was indicated: (1) that heat, in presence of water, and probably under considerable pressure, had produced rocks which bore some resemblance to, but could be distinguished from, crystalline schists, such as those of known Archæan age; (2) that, while these agents of metamorphism have produced a crystalline rock from a clastic one, they have not obliterated the original structure, when this was somewhat coarse. Hence that it is safe to conclude that, at any rate in the less highly crystalline schists, the alternation of mineral constituents which so closely simulates bedding is due to an original stratification of clastic constituents.

Physical Society, June 8.—Prof. Ayrton, F.R.S., Vice-President, in the chair.—The following communications were made:—A photograph of lightning flashes was exhibited and described by Dr. Hoffert. The photograph was obtained during the storm on the 6th inst., whilst the camera was being waved about in the hand, and shows three similar and parallel flashes, thus proving that successive sparks in multiple flashes may traverse the same path and may be separated by appreciable intervals of time. The supposed primary spark is intersected by numerous tributary ones spread out on both sides, the second spark shows one tributary, and the third none. Faint bands of light pass across the plate parallel to the direction of motion, and these prove that some residual illumination exists during the intervals between the successive flashes. Evidence of a dark flash is also presented by the plate. Prof. Herschel, who had taken photographs during the same storm, referred to the fluttering appearance of the flashes, and on their long duration; in many cases the time was sufficient to allow him to direct the camera towards the flash, and make a successful exposure. He had also observed multiple flashes with the unaided eye, and on waving his hand about he had sometimes noticed about a dozen distinct images of it during one discharge. Mr. Gregory said that he watched the storm along with two others, and they could seldom agree as to the shape of the flashes, or on their simple or multiple character. The want of agreement as to multiplicity he thought might be caused by their eyes being directed towards different parts of the sky when a multiple flash occurred; the one who happened to be looking towards the flash might be conscious of only one impression, whereas the others in directing their eyes would receive the flashes on different parts of the retina. In some cases as many as three distinct flashes (occurring at intervals of about ten seconds) traversed the same path, and a number of the discharges presented a beaded or striated appearance. The beads seemed to remain after the main flash had faded, and this might account for the bands shown in Dr. Hoffert's photograph. Mr. C. V. Boys, in referring to multiple flashes, said that although his statements made in the discussion of Mr. Whipple's paper on April 13 were not readily accepted, yet no one who watched the recent storm could doubt their existence. Prof. S. P. Thompson thought the order of the flashes on the photograph may have been the reverse of that supposed, for he observed that the band of light extended on both sides of the (so called) primary flash, whereas the outside of the third flash was quite dark. Mr. E. W. Smith noticed many cases of "sympathetic discharge," in which a flash in the north seemed to precipitate another in the north-west within a few seconds, and in this he was corroborated by Mr. Gregory, who viewed the storm from a different locality. Mr. C. V. Burton thought the heating of the air by the first spark might give rise to the tributary sparks in subsequent ones. Mr. A. W. Ward mentioned a long flash observed at Cambridge which passed from the zenith, and struck some farm-buildings at a distance, and he was particularly impressed by the considerable time occupied in its progress.—On the methods of suppressing sparking in electro-magnets, by Prof. S. P. Thompson. The object of this paper is to classify the methods which have been suggested, and to draw attention to a novel method of some importance. The classification is as follows: (1) *Mechanical devices:* (*a*) simple snap switch; (*b*) break in magnetic field; (*c*) break under liquid; (*d*) wiping break (asbestos, &c., brushes); (*e*) blow out. *Electrical devices:* (A) use of condensers, (*a*) placed across gap, and (*b*) across terminals of magnet; (B) mutual induction protectors, (*a*) copper sheath around core, and (*b*) layers of foil between windings; (C) short-circuit working; (D) differential winding; (E) high-resistance shunt (non-inductive); (F) voltameter or liquid resistance across gap; (G) multiple wire arrangement of Mr. Langdon Davies; (H) electro-magnet with two bobbins in series or parallel. The merits and demerits of the different methods are indicated. The multiple-wire arrangement used by Mr. Langdon Davies in his harmonic telegraph consists in winding each layer separately and uniting all in parallel. The effect of this is to make the time constants of the layers different, and on breaking the circuit the energy is spent in mutual discharges.—A shunt transformer, by Mr. E. W. Smith. Two conductors, A and B, of equal impedance, are placed in series between alternate current mains, and the same mains are connected through two incandescent lamps in series. The conductor A has great resistance, and B has large self-induction, and when their junction is joined to that of the two lamps, both lamps become brighter, and the main current is reduced. These phenomena were shown before the Society. Since A may consist of lamps and B may be a choking coil, the arrangement will serve to increase the P.D. between the terminals of the lamps without wasting much energy. Experiments of a similar nature have been made on a Mordey transformer wound with three equal coils. One coil was used as primary, and the other two as separate secondaries, their respective circuits consisting of lamps and an alternate current motor. Under these conditions the arithmetical run of the mean secondary currents exceeded the primary current by about 14 per cent.; the secondary volts were 8 per cent. less than the primary. All these experiments strikingly illustrate the effects of acceleration and lag in alternate current circuits, and (as was pointed out by the author) show that meters registering "ampere hours" merely, may give readings differing greatly from the numbers representing the energy used.—Notes on geometrical optics: (1) on the deduction of the elementary theory of mirrors and lenses from wave principles; (2) on a diopteric spherometer; (3) on the formula of the lenticular mirror, by Prof. S. P. Thompson. Instead of deducing the formulæ for lenses and mirrors by means of "rays," and the relations between angles of incidence, reflection, and refraction, the author considers it better to derive them from the curvatures impressed on waves at the bounding surfaces of the different media. Indices of refraction are replaced by their reciprocals, which express the relative velocities of light, and curvature is measured by the camber at the middle of chords of equal, but small, lengths. An example will assist in making the method of treatment clear. Suppose a',a', a,a two successive positions of a plane wave-front in air, which impinges on a curved surface, EAF, at A, and let the curvature at A be R, and the velocity constant of the substance h. Then, whilst the part a travels in air to h, the part in the denser medium reaches C, where $AC = h \cdot ab$, and a curvature, F, represented by BC, is impressed on the wave, which thus converges to a point Q. Since $AC = h \cdot ab = h \cdot AB$, and $\frac{BC}{AB} = \frac{AB - AC}{AB}$, $\therefore \frac{BC}{AB} = 1 - h$, and the relation between the impressed curvature and that of the surface becomes $F = R(1 - h)$. By successive application of the above method, all the ordinary lens problems may be treated,



and the resulting expressions are simplified by being expressed in curvatures. The ordinary mirror formula, $f = R$, becomes $F = 2R$, and that for the lenticular mirror, $F' = 2R + F$. The method readily lends itself to the determination of the changes in the shape of wave-fronts entering or emerging from surfaces of irregular outline. The diopteric spherometer has its outer feet situated on a circle of 44·71 millimetres radius, and is provided with a screw of 1 millimetre pitch. The instrument so constructed reads off directly in "diopteries," *i.e.* curvatures expressed on a scale in which that of a sphere of 1 metre radius is taken as unity.—On the use of the biquartz, by Mr. A. W. Ward. This is a mathematical investigation into the causes of the varying degrees of accuracy obtained by different observers who have used the biquartz in rotation measurements. Assuming that elliptically polarized light passes through the biquartz, the equation which must be satisfied to give equality of tint on the two halves is shown to be: $\cos 2\gamma \cdot \sin 2\phi \cdot \sin \overline{2\omega - \theta} = 0$, where $\tan \gamma$ = ratio of axes of ellipse, ϕ = rotation produced by quartz for wave-length λ, θ = angle between plane of vibrations of analyzer and that of xz, the axis of z being parallel to the direction of transmission, and ω = angle between one axis of the ellipse and that of x. The equation is satisfied by either $\cos 2\gamma = 0$, or $\sin 2\phi = 0$, or $\sin \overline{2\omega - \theta} = 0$. The first solution relates to circularly polarized light, and need not be considered; the second can only hold for one particular wave-length depending on the thickness of the quartz; and, in interpreting the third solution, it is shown that a satisfactory result is only obtained when the light is plane-polarized. The deductions are in accordance with experiment, for the biquartz has been used with considerable accuracy when experimenting on isotropic media; but with doubly refracting substances, where the light is liable to become elliptically polarized, the results are very discordant.

Errata.—Page 143, lines 27 and 29, for "volumes" read "densities."

Mathematical Society, June 13.—Mr. J. J. Walker, F.R.S., President, in the chair.—The President opened the proceedings of this the last meeting of the session with commenting on the losses the mathematical world had recently sustained by the deaths of Prof. Genocchi, of Turin, Prof. Du Bois-Reymond, Berlin, and M. Halphen, of Paris.—The following communications were made:—The square of Euler's series, by Dr. Glaisher, F.R.S.; a theorem in the calculus of linear partial differential operations, by Major Macmahon, R.A.; on crystalline reflection and refraction, by A. B. Basset, F.R.S.; on some rings of circles connected with a triangle and the circles (Schoute's system) that cut them at equal angles, by W. W. Taylor; the figures of the Pippian and Quippian of a class of cubic curves, by the President (Sir J. Cockle, F.R.S., in the chair); and a generalization of Buffon's problem, by Prof. Sylvester, F.R.S., (communicated by J. Hammond).—The following papers, on the small wave-motions of a heterogeneous fluid under gravity, by Prof. W. Burnside, and on the uniform deformation in two dimensions of a cylindrical shell of finite thickness, with applications to the general theory of deformation of thin shells, by Lord Rayleigh, Sec. R.S., were taken as read.

Zoological Society, June 4.—Mr. Osbert Salvin, F.R.S., Vice-President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of May 1889.—Mr. H. E. Dresser exhibited and made remarks on some eggs of the Adriatic Black-headed Gull (*Larus melanocephalus*) and of the Slender-billed Gull (*Larus gelastes*), which had lately been obtained at their nesting-places in the marshes of Andalusia by Colonel Hanbury Barclay and himself.—Dr. G. J. Romanes, F.R.S., read a paper on the intelligence of the Chimpanzee, as shown in the course of experiments made with the female Chimpanzee called "Sally," which has been living several years in the Society's Menagerie.—A communication was read from Signor Fr. Sav. Monticelli. containing notes on some Entozoa in the collection of the British Museum.—Mr. Sclater read a list of the birds collected by Mr. George A. Ramage (the collector employed by the joint Committee of the Royal Society and the British Association for the exploration of the Lesser Antilles) in Dominica, West Indies, and made remarks upon some of the species.

Entomological Society, June 5.—The Right Hon. Lord Walsingham, F.R.S., President, in the chair.—Mr. S. Stevens exhibited a specimen of *Acrolepia assectella*, Zeller, included in a lot of *Tineidæ*, purchased by him at the sale of the late Mr. A. F. Sheppard's collection. He also exhibited, for comparison, a specimen of *A. betuletella*.—Mr. J. J. Walker, R.N., exhibited a collection of Lepidoptera made in 1887 and 1888 in the immediate vicinity of the Straits of Gibraltar. The collection included sixty-eight species of butterflies, of which thirty-six were obtained on the Rock of Gibraltar itself, and the remainder on the European side of the Straits; and about 160 species of moths.—Dr. P. B. Mason exhibited a number of specimens of a South European species of ant—*Crematogaster scutellaris*, Oliv. He said that the specimens were all taken in the fernery of Mr. Baxter, of Burton-on-Trent, and had probably been imported with cork.—Mr. O. E. Janson exhibited a pair of *Neptunides stanleyi*, a species of *Cetoniidæ*, recently received from Central Africa, and described by him in the February number of the *Entomologist*; also some varieties of *N. polychrous*, Thoms., from the Zanzibar district.—Dr. N. Manders exhibited a number of Lepidoptera collected by himself in the Shan States, Burmah; also a collection of Lepidoptera made by Captain Raikes in Kárenni.—Mr. McLachlan exhibited over 400 specimens of Neuroptera, being a portion of the collection formed in Japan by Mr. H. J. S. Pryer. They represented nearly all groups (excepting *Odonata*, now in the hands of Baron De Selys). Some of the *Ascalaphidæ*, *Panorpidæ*, and *Trichoptera*, were of great beauty.—Dr. Sharp exhibited the peculiar cocoons of an Indian moth, *Rhodia newara*, Moore; these were the cocoons possessing a drain at the bottom in order to allow water to escape, already described in the Proceedings of the Zoological Society for 1888, p. 120, where, however, their great resemblance to the pods of a plant had not been alluded to.—Mr. Enock exhibited, and made remarks on, specimens of *Cecidomyia destructor*, bred from American wheat.—Mr. W. Warren exhibited a bred specimen of *Retinia posticana*, Zett., from Newmarket; also specimens of *Eupithecia jasioneata* and *Gelechia confinis*, bred by Mr. Gardner.—Mr. C. O. Waterhouse exhibited and explained a number of diagrams illustrative of the external characters of the eyes of insects.—Mr. A. G. Butler communicated a paper entitled "Descriptions of some new Lepidoptera-Heterocera in the collection of the Hon. Walter de Rothschild." He also contributed a second paper entitled "Synonymic Notes on Moths of the earlier genera of Noctuites."—Dr. Sharp read a paper entitled "An Account of Prof. Plateau's Experiments on the Vision of Insects." Lord Walsingham, Mr. Jacoby, Mr. White, and Mr. Waterhouse took part in the discussion which ensued.

PARIS.

Academy of Sciences, June 11.—M. Des Cloizeaux, President, in the chair.—On the exceptional deviations of some tropical cyclones, by M. H. Faye. As far as 35° of latitude tropical cyclones present a remarkable regularity, with the exception that the geometrical figure described by their trajectory is deflected towards the north between 20° and 30° according to the seasons, as has been clearly determined by le Père Viñez, of the Havana Observatory. But although the laws laid down by this meteorologist appeared to be absolute, they were certainly deviated from by the tornado of September 3–4, 1888, in the West Indies, as well as by that of June 1885, in the Gulf of Aden. The disturbing cause in the first instance was attributed by Viñez to a second cyclone exercising a strong repellent action on the other, and driving it with disastrous consequences across the island of Cuba. But Mr. E. Hayden, of the United States Meteorological Bureau, rejects this explanation, and traces the disturbance to the influence that zones of high pressure appear to exercise on low pressures and especially on cyclones. M. Faye seems inclined to accept this view, if it could be shown that the action of high-pressure zones is felt in the higher atmospheric regions far above the crests of the loftiest mountain ranges.—On the value of a finite continuous and purely periodical fraction, by Prof. Sylvester. The positive root of the equation

$$[{}^{\backprime}t]x^2 - ([t] - [{}^{\backprime}t'])x - [t'] = 0$$

gives the value of the purely periodical infinite fraction (t^{∞}), where t is a type—that is, a succession—of any elements whatever. By means of a formula given in a previous communication the author here offers an easy solution for the problem: To find the value of the analogous periodical but finite continuous fraction (t_n).—Researches on the elasticity of solids, by M. E. H. Amagat. The method applied by the author to crystal, as described in a former note (*Comptes rendus*, October 15, 1888), is here employed for other substances, such as glass, steel, copper, brass, and lead, which are also treated by the Wertheim process. The tabulated results, obtained at a mean temperature of 12° C., seem to show that for metals the value of Poisson's coefficient μ increases with the coefficient of compressibility, and for the other substances with the facility with which they undergo permanent deformation. The value of μ, theoretically equal to 0·50 for fluids, would appear to increase in the scale of bodies, passing through all the intermediate states (pasty, viscous, &c., and consequently for the same body passing through these various states), and approaching 0·25 according as the bodies become more and more refractory to permanent deformations—that is, more perfectly elastic. Glass approaches nearest to this theoretic condition, the next in order being steel, copper, and lead, while caoutchouc occupies the opposite extremity of the scale. Hence the perfect solid, for which the value of μ would be 0·25, should realize the double condition of being at once perfectly elastic and perfectly isotropic.—On the solubility of saccharose in distilled water, by M. Léon Périer. After the disastrous vintages of 1888 in the Gironde district, various growers attempted to substitute for the ordinary wines a drink prepared from grape-cake and sugar refermented. M. Périer here describes the results of the examination he has made of numerous specimens of these liquids submitted to his inspection.—Erosions due to wind action, by M. Contejean. During a recent visit to Corinth the author observed a remarkable instance of this phenomenon on the neighbouring plateau, where an old amphitheatre some fifteen metres from the edge of the escarpment communicates with the beach through a cavern with wide opening at both ends, and above which the limestone rock forms a natural bridge. The walls of this cavern, which is formed in the sandstone stratum at the foot of the cliff, are extremely rugged and irregularly corroded, nowhere showing traces of human workmanship. The tunnel could not possibly have been excavated either by the rains or the running waters, and its existence can be explained only by the action of the sands playing on a point of least resistance under the influence of the fierce northern gales prevalent in this region.—On the rectification of alcohol, by M. E. Sorel. In continuation of his previous communication on this subject (*Comptes rendus*, May 27, 1889), the author here shows how the theoretical data may be verified, and indicates the practical conclusions that may be drawn from them.—Some documents were submitted to the Academy by le Père Denza, on the recent earthquakes in the north-west of France, slight vibrations of which were also felt in Genoa, Sinigaglia, Sienna, and other parts of Italy. At the Observatory of Moncalieri the seismic instruments showed some indications of the underground disturbances.

BERLIN.

Physiological Society, May 31.—Prof. du Bois-Reymond, President, in the chair.—Dr. Nitze described and demonstrated his apparatus for observing and examining the interior of the urinary bladder. The apparatus, called a cystoscope, consists of a small incandescent electrical lamp, a prism, and a small ocular and objective, the whole arranged in the form of a catheter. Before making an observation the bladder is washed out with water, the instrument is then introduced, and the terminals of the electric lamp are connected with a battery. While intended in the first instance to facilitate the ocular inspection of pathological conditions of the bladder, this instrument also makes it possible to observe various physiological functions, such as the periodic extrusion of small quantities of urine from the mouths of the ureters, and the peristaltic movements of the ureters themselves. The applicability of the method was demonstrated on two patients.—Starting with the observed fact that canaries fed with cayenne pepper acquire a ruddy plumage, Dr. Sauermann has based upon it a scientific investigation of canaries, fowls, pigeons, and other birds. From these he has obtained the following results. Feeding with pepper only produces an effect when given to young birds before they moult; the colour of the feathers of older birds cannot be affected. Moisture facilitates the change of colour to a ruddy hue, which is again discharged under the influence of sunlight and cold. A portion of the constituents of cayenne pepper is quite inactive, as for instance piperin and several extractives: similarly the red colouring-matter alone of the pepper has no effect on the colour of the feathers. It is rather the triolein, which occurs in the pepper in large quantities, together with the characteristic pigment, which brings about the change of colour by holding the red pigment of the pepper in solution. Glycerin may be used instead of triolein to bring about the same result. The same statement holds good with regard to the feeding of birds with aniline colours. The red pigment of the pepper is also stored up in the egg-yolk as well as in the feathers. The first appearance of the pigment in the yolk may be observed as a coloured ring four days after the commencement of feeding with the pigment dissolved in fat; after a further two days' feeding the whole yolk is coloured. Dr. Sauermann is still engaged in carrying on his researches.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Flora of Switzerland for the Use of Tourists and Field Botanists: A. Gremli; translated by S. W. Paitson (Nutt).—Commercial Organic Analysis, vol. iii. Part 1, 2nd edition: A. H. Allen (Churchill).—Morocco: H. M. P. De la Martinière (Whittaker).—Woolwich Mathematical Papers for the Years 1880-88, edited by E. J. Brooksmith (Macmillan).—Physiological Diagrams for Use in Schools; also Index: G. Davies (W. and A. K. Johnston).—Days with Industrials: A. H. Japp (Trübner).—New Verse in Old Vesture: J. C. Grant (E. W. Allen).—Catalogue of the Fossil Reptilia and Amphibia in the British Museum (Natural History), Part 2: R. Lydekker (London).—Climatology of New Jersey (Trenton, N.J.).—Bulletin of the United States National Museum, No. 33: T. Egleston (Washington).

CONTENTS.

THURSDAY, JUNE 27, 1889.

SCIENTIFIC WORTHIES.

XXVI.—Dmitri Ivanowitsh Mendeleeff.

DMITRI IVANOWITSH MENDELEEFF was born on February 7 (N.S.), 1834, at Tobolsk, in Siberia. He was the seventeenth and youngest child of Ivan Paolowitsh Mendeleeff, Director of the Gymnasium at that place. Soon after the birth of Dmitri his father became blind, and was obliged to resign his position, and the family became practically dependent upon the mother, Maria Dmitrievna Mendeleeva—a woman of great energy and remarkable force of character. She established a glass-works at Tobolsk, the management of which for many years devolved entirely upon her, and on the profits of which she brought up and educated her large family. The story of Mendeleeff's youth is given in the preface to his great work "On Solutions," which he dedicated to the memory of his mother in a passage of singular beauty and power. Having passed through the Gymnasium at Tobolsk, Mendeleeff, at the age of sixteen, was sent to St. Petersburg, with the intention that he should study chemistry at the University, under Zinin. He was, however, transferred to the Pedagogical Institute, the aim of which was to train teachers for the District or Governmental Gymnasiums throughout the Empire. The Institute (which was abolished in 1858) was established in the same building as the University, and was divided into two Faculties—Historico-philological and Physico-mathematical. Mendeleeff attached himself to the natural sciences, and thus came under the influence of Woskresenky in chemistry, of Emil Lenz in physics, of Ostrogradsky in mathematics, of Ruprecht in botany, of F. Brandt in zoology, of Kutorga in mineralogy, and of Sawitsh in astronomy, most of whom were Professors of the same sciences in the University. Whilst at the Institute he wrote his first paper on "Isomorphism," and on the termination of his course of instruction he was appointed to the Gymnasium at Simferopol, in the Crimea. During the Crimean war he was transferred to one of the Gymnasiums at Odessa, and in 1856 he was admitted to the degree of *Magister Chemiæ* of the Physico-mathematical Faculty of the University of St. Petersburg, and was made *Privat-Docent* in the University. Even at this early period of his career we find Mendeleeff speculating on the great problems with which his name is inseparably connected. The relations between the specific gravities of substances and their molecular weights had begun to attract increased attention. Kopp had just published the first instalment of that long and laborious series of experimental observations which constitutes the real foundation of all our knowledge concerning the specific volumes of liquids, when the young Siberian philosopher laid a number of theses on problems relating to specific volumes before the Physico-mathematical Faculty of the University. He pointed out that magnetic elements have smaller specific volumes than diamagnetic elements. He also showed that Avogadro's supposition, that electro-positive elements have larger specific volumes than electro-negative elements, was in accordance with the greater number of well-established facts. When we remember how slowly, in spite of the powerful advocacy of Williamson, the ideas of Laurent and Gerhardt and what came to be known as the modern French school, found favour in this country, it is remarkable, as indicating the radical and progressive character of his mind, and the keenness of his mental vision, to find Mendeleeff, as far back as 1856, insisting that to Gerhardt was due the best mode of determining the chemical molecule; that the molecule of oxygen was expressed by the symbol O_2; those of arsenic and phosphorus by As_4 and P_4 respectively; that of alcohol by $\left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O$; and that of ether by $\left.\begin{matrix} C_2H_5 \\ C_2H_5 \end{matrix}\right\} O$.

Mendeleeff's researches on specific volumes were begun in 1855, and were continued, with intermissions, down to 1870; but part only of the work has been published. In 1859, Mendeleeff obtained permission from the Minister of Public Instruction to travel, and repaired to Heidelberg, where he established a small private laboratory, and occupied himself with the determination of the physical constants of chemical compounds. He returned home in 1861, and in 1863 was named Professor of Chemistry at the Technological Institute of St. Petersburg. In 1866 he became Professor of Chemistry at the University, and was made Doctor of Chemistry after a public defence of his dissertation "On the Combinations of Water with Alcohol." He is now Emeritus Professor, and delivers annually a course of lectures on general chemistry.

Mendeleeff is so prolific a writer that it is impossible within the limits of an article of this kind to do justice to his work. There is, in fact, no section of chemical science which he has not enriched by his contributions. Some of his earliest work related to questions of mineralogy and chemical geology; and at times, as in his papers on Œnanthol-Sulphurous Acid, on Fermentation Propyl Alcohol, and on the Nitriles, he cultivated the rapidly extending domain of organic chemistry. But his reputation mainly rests upon his contributions to physical chemistry and to chemical philosophy. In his papers on Specific Volumes he extends Kopp's generalizations, and traces the specific volumes of substances through various phases of chemical change. He shows that in the thermal expansion of homologous liquids the expansion-coefficient diminishes in a regular manner as the series is ascended, and he indicates the intimate connection which exists in the case of liquids between expansion and cohesion, and the *rôle* played by molecular cohesion in the determination of chemical activity. His paper on the thermal expansion of liquids above their boiling-points is noteworthy as demonstrating that the empirical expressions given by Kopp, Pierre, and others, for the expansion of liquids up to their boiling-points, are equally applicable to far higher temperatures, and that the expansion-coefficient gradually increases with the diminution in molecular cohesion of the liquid, until, in the case of certain liquids, *e.g.* ether at 133°, it becomes even greater than that of the gas. The expansion-coefficient of ether increases to 0·0054 at the temperature of its *absolute boiling-point*—that is, at about 190°. The absolute boiling-point is defined by Mendeleeff as that temperature at which the cohesion and latent heat of vaporization are *nil*, and at which the liquid becomes gaseous independently of pressure and volume. It is, in fact, that temperature which the researches of Andrews have made us familiar with as the "critical-point." In this paper Mendeleeff presents us for the first time with a number of determinations of the critical-temperatures of various substances, founded partly on his own determinations, and partly on those of Cagniard de la Tour, Wolff, and Drion.

Other papers on physical chemistry relate to Contact Action, to Fractional Distillation, and to the Heat of Combustion of Organic Substances. In 1883 Mendeleeff was made an honorary member of our Chemical Society, and in the following year he contributed a remarkable paper to the Journal of the Society (Transactions of the Chemical Society, xlv. 126), in which he developed an extremely simple general expression for the expansion of liquids under constant pressure between 0° and their boiling-points. This expression may be written $1/V_t = 1 - kt$, in which V_t is the volume at $t°$ (that at 0° being unity), and k is a quantity which varies with different substances, but which may for any one substance be considered invariable between 0° C. and the neighbourhood of the boiling-point. This formula is analogous to that which expresses Gay Lussac's law of the uniformity of expansion of gases. But just as Gay Lussac's formula, $V = 1 + kt$, applies only to a so-called ideal gas, Mendeleeff's expression is in like manner to be regarded only as a first approximation—that is, as applicable only to ideal liquids. The deviations are not large in either case; they are, as might be expected, especially remarkable near temperatures at which the states of the bodies change. In the case of actual liquids the deviations from the ideal form of expansion increase not only as the liquid approaches the point at which its state of aggregation is changed, but also with diminishing density, increasing cohesion, and diminishing molecular weight. This last cause is especially noteworthy since Mendeleeff showed, more than a dozen years ago (*vide supra*), that the deviations from Gay Lussac's law were related to the molecular weights of the gases. The well-known irregularities in the expansion of water are, according to Mendeleeff, connected with its small molecular weight, its high capillary constant (which expresses its cohesion), and the comparatively small temperature-interval within which its state of aggregation is unchanged. Subsequent observers, by applying Van der Waal's theory of the general relation between the pressure, volume, and temperature of bodies to Mendeleeff's expression for the thermal expansion of an ideal liquid, have shown that the reciprocal of the constant k is the number obtained by subtracting 273 from the product of the critical temperature into a quantity which should be the same for all substances. The value of this quantity is approximately 2, and since the range of its variation is apparently very small, the development of Mendeleeff's formula affords a simple and ready method of calculating the critical temperature of bodies from observations of their expansions as liquids.

Mendeleeff's skill in physical measurement is well illustrated by his determinations of the Specific Gravities of Aqueous Solutions of Alcohol. Such determinations have been frequently made the subject of the most rigorous experiment in this and other countries, inasmuch as they constitute the basis of the methods of assessing the duty on spirits, which is so important a factor in the national income of many States. Mendeleeff's work has served to confirm and extend that of Drinkwater, Fownes, and Squibb, and has been utilized by certain Continental Governments (*e.g.* that of Holland) for the purposes of revenue. But it was not the utilitarian aspect of this subject which alone attracted Mendeleeff. In a paper communicated a couple of years ago to our Chemical Society (Trans. Chem. Soc., li. 778), these determinations are applied towards the elucidation of a theory of solution in which it is sought to reconcile Dalton's doctrine of the atomic constitution of matter with modern views respecting dissociation and the dynamical equilibrium of molecules. According to Mendeleeff, solutions are to be regarded as strictly definite atomic chemical combinations at temperatures higher than their dissociation temperature, and just as definite chemical substances may be either formed or decomposed at temperatures which are higher than those at which dissociation commences, so we may have the same phenomenon in solutions; at ordinary temperatures they can be either formed or decomposed. In addition, the equilibrium between the quantity of the definite compound and of its products of dissociation is defined by the laws of chemical equilibrium, which require a relation between equal volumes, and their dependence on the mass of the active component parts (*loc. cit.* p. 779). It follows from this hypothesis that the specific gravities of solutions depend on the extent to which active substances are produced, or that the expression for the specific gravity, s, as a function of the percentage composition, p, may be represented by the general equation—

$$s = C + Ap + Bp^2.$$

Between two definite compounds which exist in solution, the differential coefficient $\frac{ds}{dp}$ is a linear function of p—

$$\frac{ds}{dp} = A + 2Bp.$$

By the application of this method to the case of aqueous solutions of ethyl alcohol, Mendeleeff infers the existence of three definite hydrates, viz. $EtHO.12H_2O$, $EtHO.3H_2O$, and $3EtHO.H_2O$, the first two of which he has isolated by subjecting the mixture to low temperatures. The hypothesis respecting the linear character of the differential coefficient $\frac{ds}{dp}$ has been proved to be correct for solutions of many salts, of acids, and of ammonia.

We have the consummation of this work on solution in the monograph published by Mendeleeff last year. This volume, the fruit of many years of labour, is unquestionably the most important contribution to the theory of solution yet given to science.

Much of Mendeleeff's scientific activity since 1871 has been absorbed in an extended work on the elasticity of the gases, which he has executed in conjunction with his pupils, Kirpitshoff, Hemilian, Bogusky, and Kajander. Part only of the results have as yet appeared. The first volume, published in Russian in 1875, contains details of the modes of measurement, which involved many forms of apparatus new to physical science. A summary of the principal results obtained was published in the form of a pamphlet in 1881. Regnault found that the product

$p . v =$ const.—*i.e.* Boyle's law—was true for ideal gases only. Between one atmosphere and thirty atmospheres the deviations were positive in the case of hydrogen, and negative in those of all other gases. Mendeleeff pointed out that the deviations must become positive for all gases at sufficiently high pressures, and the fact has since been confirmed by the observations of Amagat and Cailletet. Mendeleeff, more particularly, made observations at low pressures, *i.e.* below one atmosphere; and here the deviations were again found to be positive and relatively very large. It was found, in fact, that, at the limit of condensation, the gases seemed to behave like solid bodies—*i.e.* the molecules were incapable of being stretched or brought nearer together to any appreciable extent by varying pressure. Mendeleeff has further determined the *real* coefficients of thermal expansion of gases. This, for air between 0° and 100° under a standard atmosphere, was found to be 0·0036829. Determinations made in the case of other gases have shown that the coefficients of expansion increase with increasing molecular weight, gases of the same molecular weight giving the same coefficient.

	Molecular weight.	Coefficient of expansion.
Hydrogen	2	0·00367
Nitrogen / Carbon monoxide	28	0·00373
Nitrous oxide / Carbon dioxide	44	0·00373
Sulphur dioxide	64	0·00385
Hydrogen bromide	81	0·00386

The coefficient of expansion is found to decrease with increasing pressure in the case of hydrogen. Thus at

200 mm.	0·00369
760 ,,	0·00367
8 atmos.	0·00366

But with the so-called coercible gases the reverse is found to take place. Thus, in the case of carbon dioxide,

120 mm. pressure	0·00372
220 ,, ,,	0·00370
760 ,, ,,	0·00373
3 atmos. ,,	0·00389
8 ,, ,,	0·00413

The decrease of the coefficient of expansion with increasing pressure is a normal phenomenon of gases, the positive deviation observed in the case of hydrogen being found to hold equally good for all gases at very high and very low pressures. Hence the laws of Boyle and Charles are only valid at points of the curve when the deviation changes from positive to negative or *vice versâ*.

These experiments have also borne fruit in various meteorological papers on the physical nature of the highly rarefied air existing in the upper strata of the atmosphere. In this connection it may be stated that Mendeleeff has attempted to organize meteorological observations in the upper regions of the atmosphere by means of balloons, and hence he has been led to study aëronautics. His practical acquaintance with the subject induced him to make an ascent from Klin during the total solar eclipse of August 19, 1887, for the purpose of observing the extension and structure of the corona when seen through highly rarefied air.

Russia is indebted to Mendeleeff for the training of two generations of her chemists. His writings have largely modified the mode of teaching chemical science in that country. His treatise on Organic Chemistry was the standard work of its time, and exercised great influence in spreading abroad the conceptions which are associated with the development of modern chemistry. His "Principles of Chemistry," published in 1869, and repeatedly reprinted, is a veritable treasure-house of ideas, from which investigators have constantly borrowed suggestions of new lines of research. This book is one of the classics of chemistry; its place in the history of science is as well assured as the ever-memorable work of Dalton. Mendeleeff, indeed, might with equal fitness have styled his book a "New System of Chemical Philosophy." In it he has developed the great generalization which is known under the name of the "Periodic Law"—a generalization which is exerting a profound influence on the development of chemical science in all countries in which its study is actively prosecuted. Mendeleeff first drew attention to the principles upon which the Periodic Law is based in a paper read to the Russian Chemical Society in 1869, in the following series of propositions:—

(1) The elements, if arranged according to their atomic weights, exhibit an evident *periodicity* of properties.

(2) Elements which are similar as regards their chemical properties have atomic weights which are either of nearly the same value (*e.g.* platinum, iridium, osmium), or which increase regularly (*e.g.* potassium, rubidium, cæsium).

(3) The arrangement of the elements, or of groups of elements in the order of their atomic weights, corresponds to their so-called *valencies*, as well as, to some extent, to their distinctive chemical properties; as is apparent among other series in that of lithium, beryllium, barium, carbon, nitrogen, oxygen, and iron.

(4) The elements which are the most widely diffused have *small* atomic weights.

(5) The *magnitude* of the atomic weight determines the character of the element, just as the magnitude of the molecule determines the character of a compound body.

(6) We must expect the discovery of many yet *unknown* elements—for example, elements analogous to aluminium and silicon—whose atomic weight would be between 65 and 75.

(7) The atomic weight of an element may sometimes be amended by a knowledge of those of its contiguous elements. Thus the atomic weight of tellurium must lie between 123 and 126, and cannot be 128.

(8) Certain characteristic properties of elements can be foretold from their atomic weights.

In the Faraday Lecture recently delivered to the Chemical Society, and from which these words are taken, Mendeleeff has indicated for us the lines upon which the evolution of his theory proceeded. In the first place, it is to be noted that it is based wholly on experiment: it is as much the embodiment of fact as are the laws of chemical combination formulated by Dalton. Without the knowledge of certain data it could not possibly have been discovered; with this knowledge its appearance, says Mendeleeff, is natural and intelligible. Three series of data were necessary to pave the way for its enunciation:—

(1) The adoption of the definite numerical values of the atomic weights founded on the conceptions of Avogadro and Gerhardt, as insisted upon by Cannizzaro.

(2) The recognition that the relations between the atomic weights of analogous elements were governed by some general law. Many chemists, and more especially Dumas, Gladstone, and Strecker, had drawn attention to the numerical relationship existing between correlated groups of elements, but no one before Newlands in England, and De Chancourtois in France, had sought to generalize this conception, and to extend it to all the elements by considering their properties as functions of their atomic weights. (3) A more accurate knowledge of the relations and analogies of the rarer elements, such, for example, as that given to us by Roscoe in the case of vanadium, and by Marignac in that of niobium. The law of periodicity was the systematized expression of these data; it was, to use Mendeleeff's language, "the direct outcome of the stock of generalizations of established facts which had accumulated by the end of the decade 1860–70."

We can only very rapidly allude to some of the more striking services which Mendeleeff's generalization has rendered to science during the twenty years of its existence. By a more systematic arrangement and co-ordination of the known chemical elements, it has not only indicated the existence of new forms of elementary matter, but it has pointed out the probable sources of the undiscovered substances, and has enabled us to know their properties even before we have knowledge of their existence. It was this power of divination inherent in the law which, perhaps more than any other feature, first attracted attention to it, and quickened the interest with which its development was regarded by men of science. There are now three instances of elements of which the existence and properties were foretold by the periodic law: (1) that of *gallium*, discovered by Boisbaudran, which was found to correspond with the *eka-aluminium* of Mendeleeff; (2) that of *scandium*, corresponding to *eka-boron*, discovered by Nilson; and (3) that of *germanium*, which turns out to be *eka-silicium*, by Winckler. No one who was present on the occasion of the delivery of the Faraday Lecture will forget the enthusiasm which followed the reading of these words of Mendeleeff's: "When, in 1871, I described to the Russian Chemical Society the properties, clearly defined by the periodic law, which such elements ought to possess, I never hoped that I should live to mention their discovery to the Chemical Society of Great Britain as a confirmation of the exactitude and the generality of the periodic law."

Up to the time of the formulation of the law, the determination of the atomic value or valency of an element was a purely empirical matter, with no apparent necessary relation to the atomic value of other elements. But to-day this value is as much a matter of *a priori* knowledge as is the very existence of the element or any one of its properties. Striking examples of the aid which the law affords in determining the substituting value of an element are presented by the cases of *indium*, *cerium*, *yttrium*, *beryllium*, *scandium*, and *thorium*. In certain of these cases, the particular value demanded by the law, and the change in representation of the molecular composition of the compounds of these elements, have been confirmed by all those experimental criteria on which chemists are accustomed to depend. One of the most interesting instances of the kind is seen in the example of *uranium*, the atomic weight of which was formerly regarded as 120, then as 180, but which, on the authority of the periodic law, is now established as 240, a value completely confirmed by the independent experiments of Zimmermann and Rammelsberg. Uranium has a special interest in being the last term in the series: no element of higher atomic weight is at present known.

As examples of the value of the law in enabling us to correct the atomic weights of elements whose valencies and true position were well known, we may cite the cases of *gold*, *tellurium*, and *titanium*, the values of which were apparently higher than those demanded by it. In each of these cases a redetermination of the atomic weight has resulted in a value which is in conformity with the previsions of the periodic law.

The law has, moreover, enabled many of the physical properties of the elements to be referred to the same principle of periodicity. At the Moscow Congress of Russian physicists in August 1869, Mendeleeff pointed out the relations which existed between the density and the atomic weights of the elements; these were subsequently more fully examined by Lothar Meyer, and are embodied in the well-known curve in his "Modern Theories of Chemistry." Similar relations have been discovered in certain other properties, such as ductility, fusibility, hardness, volatility, crystalline form and thermal expansion; in the refraction equivalents of the elements, and in their conductivities for heat and electricity; in their magnetic properties and electro-chemical behaviour; in the heats of formation of their haloid compounds; and even in such properties as their elasticity, breaking stress, &c.

In the Faraday Lecture, Mendeleeff indicated the bearing of the law of periodicity upon the doctrine of constant valency, and especially on the conception of a primordial matter. The mind almost instinctively clings to the notion that the law can only find its rational interpretation in the idea of unity in the formative material, and it is not surprising that the promulgation of the law has been heralded by some as the most convincing proof of the validity of the Pythagorean conception that experiment has yet been able to adduce. But the author of the periodic law will not admit that his generalization has either sprung from this conception or has any relations towards it. "The periodic law, based as it is on the solid and wholesome ground of experimental research, has been evolved independently of any conception as to the nature of the elements; it does not in the least originate in the idea of an unique matter; and it has no historical connection with that relic of the torments of classical thought; and therefore it affords no more indication of the unity of matter or of the compound nature of the elements than do the laws of Avogadro and Gerhardt, or the law of specific heats, or even the conclusions of spectrum analysis. None of the advocates of an unique matter has ever tried to explain the law from the standpoint of ideas taken from a remote antiquity, when it was found convenient to admit the existence of many gods—and of an unique matter."

No record of Mendeleeff's intellectual activity would be complete without some reference to his influence on the development of the industrial resources of Russia. In 1863 he brought out the first encyclopædia of chemical technology of any magnitude which the literature of that country possessed, and he has been frequently commissioned to report on the progress of chemical industry as manifested at the various International Exhibitions. But it was on the petroleum industry of Baku, on the Caspian, that this influence has been most widely felt. Fifteen years ago the production of petroleum in Russia was a monopoly, and was accompanied by all the evils which usually spring from monopolies: the trade was exceedingly limited, and apparently incapable of development. Thanks largely to his action, both on the platform and in the press, the opening up of the boundless supplies of the peninsula of Apsheron was thrown open to the world, with the result that petroleum threatens to effect an industrial revolution in Eastern Europe and in Asia. Indeed, it is not too much to say that the oil industry of Baku is rapidly becoming, directly and indirectly, one of the most powerful factors in the Central Asian problem. Mendeleeff's interest in the development of the Baku industry has led to his being sent to the Caucasus and to Pennsylvania, to report upon the best modes of working the wells, and of separating and utilizing the products. Last year, during the coal crisis in Southern Russia, he was commissioned to study the economic condition of the industry in the rich coal-basin of Donetz.

No man in Russia has exercised a greater or more lasting influence on the development of physical science than Mendeleeff. His mode of work and of thought is so absolutely his own, the manner of his teaching and lecturing is so entirely original, and the success of the great generalization with which his name and fame are bound up is so strikingly complete, that to the outer world of Europe and America he has become to Russia what Berzelius was to Sweden, or Liebig to Germany, or Dumas to France. Nowhere has Mendeleeff's pre-eminence been more quickly or more fully recognized than in this country. English men of science and of learning have delighted to do him honour. In 1882 the Royal Society gave him the Davy Medal; and now, the Chemical Society, which is proud to number him among its Honorary Fellows, has conferred upon him the highest distinction in its power, by the award of the Faraday Medal. To the great regret of the large gathering of British chemists which had assembled to welcome him and to listen to the memorable address on the subject which he of all others is best fitted to expound, Mendeleeff was unable to receive the gift in person; but the circumstances of his absence awakened a deep feeling of commiseration and sympathy, and served to intensify the sentiment of respect and admiration with which he is regarded by all English men of science.[1]

T. E. THORPE.

THE PREVENTION OF HYDROPHOBIA.

AS was foretold three years ago, by those experienced in its behaviour, rabies is again making itself felt in this country by becoming epidemic. No disease probably has been more misunderstood in the past, none is more clearly known to-day. We are not therefore, as in 1885, caught napping. Since M. Pasteur showed us the whole story of rabies, we have acknowledged the brilliancy of his researches and the most gratifying discovery he made of the way in which the disease may be prevented from developing in any individual unfortunately bitten by a rabid dog. The manner too in which he gradually unfolded one secret of Nature after another, by his extraordinary insight into the phenomena of infectious disease, has been demonstrated with beautiful clearness in the recent Croonian Lecture delivered by Dr. Roux before the Royal Society.

The gradual evolution of the science of preventive inoculations by M. Pasteur has taught us how to obviate the appearance of rabies or hydrophobia when the virus has been introduced into the system; how, in fact, the virus may be hindered from exerting its frightful effects on the nervous centres of those unfortunately exposed to the danger. Consequently he enjoys the supreme pleasure of having saved hundreds, not only from a most painful and miserable death, but from what is actually far more painfully important—the most dreadful of apprehensions.

But this last point, the apprehension or dread of the disease, which is so appalling a feature of this malady, owing to the extraordinary length of its incubation period, has forced upon everyone save the anti-vivisectionists, the fact that it is far more necessary, in this of all troubles, to prevent the chances of the mischief occurring, than to try and shut the door after the evil has found admission. We have persistently urged that in islands like Great Britain the mere existence of rabies is a matter of the greatest reproach; that preventive legislation is to a very unusual degree able to cope with it and destroy it utterly. A brief repetition of the grounds of this belief will not be out of place. Of all acute specific diseases, rabies is evidently the one in which the virus survives removal from living tissues with the greatest difficulty. As retention of virulence and viability by the viruses of different acute specific diseases is a subject of the highest interest, as well to the practical hygienist as to the pathologist, we fortunately know enough from the work of recent years to speak with confidence on the point. Bacteriological experience has shown that the difficulty of artificially cultivating a zymotic virus in dead material, *e.g.* gelatine, increases, roughly speaking, in proportion to the length of the incubation period. In proof of our contention we may quote the extreme cases of tuberculosis and anthrax. In the former disease the virus is a slow-growing bacillus, growing in artificial cultures with the utmost difficulty, and destroying life only at the end of many weeks. In anthrax, on the contrary, we have a bacillus which develops with the utmost activity on artificial nutrient soils, and which kills in a few hours.

Duration of incubation period, however, is not necessarily an index to the viability of a bacillus. But while it was clear from what has just been said that we were *a priori* fully justified in prophesying that the rabic virus would probably not develop in the absence of a living pabulum, *i.e.* living tissue, we have actual evidence to show that fortunately this most terrible virus in all probability is not possessed of powers of active resistance to those injurious influences which act upon it

[1] I have to express my grateful acknowledgments to Prof. Menshutkin and M. Gorboff, of St. Petersburg, and to Dr. B. Brauner, of the University of Prague, for much of the information on which this article is based.—T. E. T.

when exposed to the air, &c. This evidence is simply the fact that no case bears investigation in which the poison was asserted to have been found infecting the ground, woodwork, &c., of places habited by rabid animals—that, in short, the rabic virus cannot survive the drying, changes of temperature, &c., it necessarily undergoes when scattered over the ground, as we often see happen by the slobbering of a rabid animal.

This is the first and a most important point, upon which our opinion was based. We pass now to the second, which is to a certain extent the corollary of the first. It is, that the disease is communicated only by one animal biting another. There is really no evidence to show that accidental inoculation with the blood, &c., has ever occurred, and we are now in possession of direct experimental evidence to show that the poison cannot be absorbed, by being combined with food, through the mucous membrane of the alimentary canal. The only practicable mode of transmission of the disease, therefore, is by one animal biting and lacerating another's tissues, or by licking a wound and so introducing the virus.

This point, coupled with the first, establishes irrefragably the proposition that, for the permanent extinction of rabies from a country into which its reintroduction can reasonably be prevented, it is only necessary to prevent rabid animals from biting healthy ones. In other words, it is only necessary to apply the muzzle. Usually the public does not listen to scientific men, unless the matter happens to be one where their own experience, favourable or unfavourable, serves to help them to a conclusion. On the present question the experience of London in 1885 and 1886 is sufficient; and from the recent memorial of the County Council addressed to the Privy Council, the knowledge gained by the last epidemic has been speedily utilized. But, with particular wisdom the County Council have asked for the general adoption of the muzzle all over the country, so that we may have not merely a temporary extinction of the disease in one locality, but a riddance of it from the whole country. It might well be asked, Why have not the Privy Council, who hold in their hands the machinery of prophylactic legislation, brought this consummation to a perfect conclusion without waiting to be urged by the public outcry which it was well known would certainly be raised sooner or later, according as rabies rapidly or slowly increased? The answer is simple, being nothing more than the well-known cowardice of authorities to interfere with what they believe to be a popular interest, sentiment, or feeling, on any point, however contrary to reason or fact that sentiment may be. The Select Committee of the House of Lords, whose Report we reviewed two years ago, did yeoman service to the cause by collecting an immense amount of valuable evidence; but unfortunately, misled by the interests falsely stated to be interfered with, reported adversely to a general adoption of muzzling regulations all over the country, and advised leaving the whole matter in the hands of the local authorities.

Even those members of the Upper House who were most interested in the subject, both from philanthropic and agricultural reasons, hesitated to support any measure which might involve some trouble in application. We allude of course to the muzzling of sporting dogs more especially, and to the exemption of sheep and other dogs actually engaged in work. All these points were considered fully two years ago by the Society for the Prevention of Hydrophobia, a Society composed of dog owners and scientific men, and were treated by them in the provisional draft of a Bill which provided for each of the cases referred to. Fortunately this Bill will be introduced into the Lower House by Sir Henry Roscoe, so that the question will now be brought to a very definite head.

Nothing, however, in the way of philanthropic reform is said ever to succeed unless it is violently opposed. Violent opposition to the present proposals has assuredly not been wanting, nor will apparently be wanting. At the time of the last epidemic, and ever since, the anti-vivisectionists, turning from vilifying M. Pasteur's charitable efforts, maligned the police, and, to parody the celebrated dictum of Spinoza, first asserted that there was no such thing as rabies; secondly, that it was contrary to religion (of humanity); and thirdly (this only recently), that the disease was well known, but did not require preventing.

The diatribes of these people may be amusingly ridiculous, but naturally they are also mischievous. It is scarcely conceivable, in this present century of intelligence, that none of their subscribers should have seen that they are really opposing the only known means of counteracting rabies, and that their money is consequently being spent to perpetuate this terrible infliction among us. However, the infallible test of time is fortunately dispersing the mists of falsehood which have been so carefully spread around the subject.

M. Pasteur's splendid achievements have, as all scientific truth must, contributed greatly to the success of the movement for obliterating the curse from this country. For, attracted by the value of the work of the Pasteur Institute, and its single-mindedness, the Prince of Wales and the Lord Mayor of London have recently visited it, have seen the immense importance of the researches carried on in the laboratory there, and they are in consequence greatly desirous of providing similar blessings for this country. The Lord Mayor, in order to give effect to the opinions he has so strongly formed, has summoned a meeting at the Mansion House for July 1, at 3 p.m., and the Prince of Wales will write a letter in support of the same. At the last meeting of the Royal Society for the present session, held on Thursday, the 20th instant, the Society adopted a letter which had been drawn up by the President and Council, expressing sympathy with the Lord Mayor's attempt to obtain some public recognition in this country of the services rendered by M. Pasteur to science and humanity, and appointing the officers with Sir James Paget, Sir Joseph Lister, Sir Henry Roscoe, and Prof. Lankester, as their representatives at the meeting called by the Lord Mayor.

The whole business of the meeting will be devoted to, first, the providing of a sum of money to be paid to the funds of the Pasteur Institute as a slight acknowledgment of the great benefits which the Institute has gratuitously extended to over 200 of our fellow-countrymen threatened with rabies; secondly, the formation of a fund to cover the expenses of poor people travelling to Paris for inoculation and unable to support themselves; and thirdly, a strong resolution calling upon the Privy Council to instantly inaugurate such muzzling and other restrictive measures as shall definitely and finally exterminate rabies. The anti-vivisection agitators, whose object it is apparently to keep alive rabies in this country, have opposed the meeting, which we hope will be crowded by genuine lovers of men and animals. The form their opposition has taken is amusing to the last degree, since it consists of a petition, advertised in the daily papers, made of four or five headings, each of which may be called in question. In the very first paragraph it is stated that the Manager of the Dogs' Home in Battersea has passed a large number of dogs through his hands, and that he never saw a case of rabies among them. If this means that there has never been a case of rabies at the dogs' home, we believe evidence can be produced to the contrary.

The innate falsity of this agitation is always making itself felt, and it is nothing more than Nemesis that the statements made by agitators in the hope of deceiving the public, should be detected and exposed again and again. Such a statement as that asserted to have been made by the Manager, even if he did make it, has no value in view of the incontrovertible facts of the police records of the existence—nay, more, of the increase — of rabies in London. The Mansion House meeting will do much to blow away this miserable opposition, which attacks biological science alone, knowing full well that no false sentiment can be hashed up against physical science and its benefits to mankind. The object of the meeting is to honestly acknowledge our great indebtedness to M. Pasteur, to provide for our poorer fellow-countrymen gaining the benefits of the Pasteur Institute, and, finally, to stamp out rabies.

No scientific man who really has the interests—in fact, the honour—of his country at heart will refuse his support on this important occasion; and we may well hope that many will be found able to attend the meeting personally, to render the occasion worthy of the great chemist whose work has so essentially led to the successful performance of the hygienic measures now about to be executed.

STELLAR EVOLUTION.

Stellar Evolution and its Relation to Geological Time. By James Croll, LL.D., F.R.S. (London: Edward Stanford, 1889.)

DR. CROLL'S book, though chiefly dealing with the question of stellar evolution from the astronomer's point of view, calls in the evidence afforded by geology in favour of the theory which is set forth in its pages. The particulars of the theory are clearly stated, and the new facts which have been gathered since the theory was first published are fully considered.

Dr. Croll accepts the nebular hypothesis of Kant and Laplace, and deals mainly with the question of the pre-nebular condition. According to his theory, large cool dark bodies, moving with enormous velocities, were either created or were eternal; and these colliding with each other here and there, the evolution of the celestial bodies was accomplished. With regard to the origin of these bodies endowed with motion, Dr. Croll states:—"We are perfectly at liberty to begin by assuming the existence of stellar masses in motion; for we are not called upon to explain how the masses obtained their motion, any more than we have to explain how they came into existence. If the masses were created, they may as likely have been created in motion as at rest; and if they were eternal, they may as likely have been eternally in motion as eternally at rest" (p. 3). It is argued that the heat energy which would have been derived from gravitation alone could not possibly have been equal to that which the solar system originally possessed. But there is absolutely no limit to the amount of available energy from Dr. Croll's point of view. The most important argument against the gravitational theory is undoubtedly the geological and biological one. The whole question of geological time rests on an estimation of the time during which the sun has been radiating its heat, and on this point Dr. Croll remarks: "If gravitation be the only source from which the sun has derived its heat, then life on the globe cannot possibly date farther back than 20,000,000 years, for under no possible form could gravitation have afforded, at the present rate of radiation, sufficient heat for a longer period" (p. 35). The adoption of Langley's value (1·7 times that of Pouillet) for the rate of solar radiation reduces Helmholtz's estimate of 20,000,000 years to 12,000,000 years, and even this would not be available for plant and animal life, as millions of years must have undoubtedly elapsed before the earth was prepared for them. Prof. Tait ("Recent Advances in Physical Science," p. 175) has shown that, from the physical point of view, "10,000,000 years is about the utmost that can be allowed for all the changes that have taken place on the earth's surface since vegetable life of the lowest known form was capable of existing there." Sir William Thomson states his conclusions on this point thus: "In the circumstances, and taking fully into account all possibilities of greater density in the sun's interior, and of greater or less activity of radiation in past ages, it would, I think, be exceedingly rash to assume as probable anything more than 20,000,000 years of the sun's light in the past history of the earth, or to reckon on more than five or six million years of sunlight for time to come" ("Popular Lectures and Addresses," p. 390).

It is not necessary here to enter into details of the various methods by which geologists and biologists have attempted to estimate the length of time which must have elapsed since the earth first received the heat of the sun. On this point Dr. Croll says: "The grounds upon which the geologists and biologists found the conclusion that it is now more than twenty or thirty millions of years since life began on the earth are far more certain and reliable than the grounds upon which the physicist concludes that the period must be less" (p. 68). Here again, it may be well to quote Sir William Thomson, who says:—"What then are we to think of such geological estimates as 300,000,000 years for the 'denudation of the Weald'? Whether is it more probable that the physical conditions of the sun's matter differ 1000 times more than dynamics compel us to suppose they differ from those of matter in our laboratories; or that a stormy sea, with possibly channel tides of extreme violence, should encroach on a chalk cliff 1000 times more rapidly than Mr. Darwin's estimate of one inch per century?"[1]

But granted that the geological evidence is against the gravitation theory, it remains for us to see how Dr. Croll's theory bears the strain put upon it when the details of the evolutionary processes are inquired into.

According to the impact theory of Dr. Croll, "meteorites are but the fragments of sidereal masses which have been shattered by collision" (p. 12). The result of such a collision would be mainly to produce a gaseous mass, but some of the exterior fragments would have velocities sufficient to carry them beyond the influence of the central mass. This view is obviously in direct contradiction to the opinion held by Mr. Lockyer, who looks upon meteorites as the parents, and not the children, of sidereal systems. The explanation of the thumb-marks and the heterogeneous structure of meteorites which has been given by Mr. Lockyer (Proc. Roy. Soc., vol. xliii. p. 151) would apply equally to Dr. Croll's view.

Comets, according to the impact theory, have a similar origin to meteorites, Dr. Croll apparently agreeing that they are nothing more than swarms of meteorites. Those with elliptic orbits probably had their origin in the collision which produced the nebula out of which the solar system has been evolved, whilst those with parabolic and hyperbolic orbits are probably the outcasts of other systems.

The first condition of a nebula, according to Dr. Croll, is that in which it consists of broken fragments scattered through a gaseous mass of excessively high temperature. Mr. Lockyer's recent researches are consistent with this view, as far as meteorites and interspaces are concerned, but they point to the opposite conclusion with regard to temperature. Mr. Lockyer's spectroscopic work has shown that the highest temperature is in all probability only reached by a nebulous mass after the complete volatilization of all the meteorites composing it, and he has shown that the intermediate stages which should occur on this supposition are actually represented amongst the stars, the stars of Group II. being amongst these. This therefore furnishes a strong argument against the high-temperature theory of nebulæ.

According to the impact theory of Dr. Croll, the meteorites scattered through the gaseous mass have nothing whatever to do with the luminosity; whereas, from Mr. Locker's point of view, the luminosity is in great part, if not entirely, due to collisions between the meteorites. Dr. Croll objects to this latter view because it "does not appear to afford any rational explanation of this banging about of the stones to and fro in all directions; for, according to it, the only force available is gravitation, and this can only produce merely a motion of the materials towards the centre of the mass" (p. 20). Dr. Croll has evidently given but little thought to this theory, originally advanced by Prof. Tait, for it is obvious that all the meteorites would not lose all their momentum by collisions during their first movements towards the common centre of gravity. Those which escaped collision would move on beyond the centre of gravity with considerable velocities, and would continue to oscillate to and fro until all their momentum was converted into heat by collisions. The banging about might therefore go on for a very long time, and the observations made by Dunér, and classified by Mr. Lockyer, show that this is probably the case. The increase of temperature would accordingly take place gradually, and not suddenly, as Dr. Croll supposes; and further, the highest temperature would be associated with a certain class of stars, and not with the nebulæ themselves.

The subject of new stars is dismissed with very few words. The general view adopted by Dr. Croll seems to be that in such a case as Nova Cygni the outburst was due to the collision of a star with a swarm of meteorites. The spectroscopic evidence in favour of Mr. Lockyer's view, that such an outburst is due to the collision between *two* swarms of meteorites, is not even referred to. The case of Nova Cygni, indeed, has an important bearing on theories of cosmogony. Its spectrum, as observed by Copeland when it was just fading from our view, was that of a planetary nebula. If, therefore, a nebula is at a higher temperature than a star, Nova Cygni must have got hotter as it got dimmer!

Dr. Croll shows that his theory explains other details of the structure of our universe, including the proper motions of stars and the origin of binary systems, but these need not be more than mentioned.

Assuming that Dr. Croll has established that gravitation alone would have been incompetent to produce the heat originally possessed by the solar nebula, it is only necessary to reconcile this with the low-temperature theory of nebulæ, as the high-temperature theory has been shown to be inconsistent with the facts.

It may be suggested that instead of the dark stellar masses endowed with motion which Dr. Croll supposes to have been the pre-nebular condition, meteorites at great distances apart were endowed with similar velocities. In the first groupings, the collisions would only occur very rarely, and there would be more grazes than anything else, so that the average temperature might still be low in the earlier stages. Prof. G. H. Darwin[1] has recently shown that the conception of fluid pressure which is demanded by Laplace's nebular hypothesis is not difficult to reconcile with the meteoritic hypothesis. If we substitute meteorites in collision for the molecules of a gas impinging against each other, there would be a quasi-fluid pressure as the average result of the impacts of the meteorites, and the separation of the planets from the meteor-swarm would take place exactly as in a gaseous mass.

A. FOWLER.

[1] *Macmillan's Magazine*, March 1862; reprinted in "Popular Lectures and Addresses," p. 361 (Macmillan, 1889).

[1] Phil. Trans., vol. cclxxx. pp. 1–69.

THE TELEPHONE.

The Telephone. By William Henry Preece, F.R.S., and Julius Maier, Ph.D. Pp. i-xvi., and 1-498. (London: Whittaker and Co., 1889.)

THIS book is one of the "Specialists' Series" of technical manuals now being issued by Messrs. Whittaker and Co. Its aim is to give as full an account as possible of telephony as a practical art, and the authors have certainly succeeded in inclosing within the compass of a handy octavo volume a vast amount of well-arranged information on a subject hitherto unrepresented in English by any systematic treatise. After two chapters, comprising about twenty pages, on sound and speech, and on such parts of electrical theory as are more immediately connected with the action of the telephone, the authors proceed to deal with the construction of the telephone, and treat in detail the subject of transmitters and receivers of all kinds. This part of the book is very interesting, giving as it does an account of the principal forms of telephone receivers and transmitters which were the outcome of the marvellous activity of telephonic research aroused by the publication of the inventions of Bell, Edison, and Hughes. In chapter x. come telephone lines and cables, and modes of installing them; then chapters on auxiliary apparatus, and on terminal and intermediate stations, lead up to the important subject of telephone exchanges, and appliances connected with their working, to which chapters xiv. to xx. are devoted. Long-distance telephony is introduced in chapter xxi., and systems of translation between the terminal networks, and the return wire or other induction avoiding circuit between the two places, are fully described. Various problems of practical telephony are then discussed, such as multiplex telephony, and the numerous devices for enabling several subscribers to work in one circuit. Chapters on the telephone as applied to the telegraph service, its military uses in camp and in the field, and finally some miscellaneous although important scientific applications of the instrument, conclude the work.

Of the main body of the work the contents of which are briefly analyzed above, we have no remark to make that is not commendatory. As has been already indicated, the work is full of most valuable practical details of actual working systems of telephony. The descriptions of complicated apparatus and appliances are full and clear, and bear everywhere the stamp of the work of men accustomed to exposition, and professionally acquainted with the subjects of which they treat.

In our examination of the work, we have noted a few points in which perhaps improvement might be effected in a second edition. Most of these occur in the preliminary chapters on the theory of the telephone, a part of the subject in some ways much more difficult to treat successfully than that which follows. For example, such a phrase as that on p. 14—that in a current following the simple harmonic law of variation with the time the electricity flowing is, "so to speak, thrown into undulatory motion"—is very apt to create an erroneous impression on the mind of a learner, and in no way describes what actually takes place. What is thrown into undulatory motion is not the electricity conveyed but the medium which forms its vehicle.

On p. 16 the phenomena of induction of currents are hardly "described with due precision." It is stated that "if there be a magnetic field, and a conductor in that field, any change in that field will produce the conditions that determine a current in that conductor." No doubt it is stated immediately afterwards that, "if a conductor forming part of a closed circuit be moved *across* a magnetic field in a direction at right angles to the lines of force in that field, a current will be induced whose strength is proportional to the strength of the field and to the rate at which the conductor cuts across the lines of force," but it nowhere appears that a change of the magnetic induction through the circuit is the one determining condition of an induced current. The authors, indeed, as if to sum the matter up, conclude this passage with the unqualified statement, which, as it stands, is not true except under certain conditions which are not stated: "In fact, currents are produced in a closed circuit placed in a magnetic field, whenever any change whatever occurs in the intensity of that field." If the circuit be so placed in the field that there is zero magnetic induction through it, the field may be absolutely annulled without producing any current whatever.

Again, on p. 18 it is stated that "the energy of the current in a coil at any moment is expressed by the product of the electromotive force (E) at the terminals of the coil producing the current, and the current itself (C), that is, W = E C." Now, what is here called the "energy of the current" is in reality the *activity* or time-rate of working of the current. The energy of the current at any instant is the energy which would be evolved in the form of a spark, or otherwise, if the current in the circuit were at that instant annulled. It is just this kind of misuse of the word energy that has led to the popular confusion (very common among the so-called "practical" (!) men who have applauded the Quixotic crusade against theory and "theoreticians") between work and rate of working, and to the astounding proposition, not yet exploded in all quarters, that the efficiency of a motor is a maximum when half the whole energy spent is wasted.

There are various other points and some omissions in the introductory and theoretical portions which we had noted. The remarks on self-induction might be improved, and it would have been well to point out here that conductors carrying rapidly-alternating currents (and telephone wires certainly do this) have, as Lord Rayleigh has shown, a virtually increased resistance due to the concentration of the current in the outer part of the wire. Another point is the apparently unguarded application, made at pp. 123, 124, of the results of the theory of a slowly worked submarine cable to the transmission of the rapidly alternating currents of telephones. The state of the case is much less simple than the authors here make it appear. Also, it is not possible, with any approach to accuracy, to regard copper wires, in this connection, as "virtually free from electro-magnetic inertia." But we have said enough as to these blemishes. They can be removed by careful extension and rewriting of the introduction. After all, it ought to be recognized that it is impossible to give in a book on a branch of electrotechnics any statement of theory which can supersede that full and detailed treatment which is indispensable, and which must be sought in systematic treatises on electrodynamics.

As to the more purely technical portion of the work, we have only to repeat that it is full and trustworthy, and, moreover, remarkably well illustrated. There are several statements made by the authors which might be questioned, but as these are in many cases matters of opinion rather than of actual fact, we need not enter into them.

In conclusion, we have to say that this book is a striking testimony to the rapid development of telephony. Thirteen years ago the first rude model of a telephone was brought from America by Sir William Thomson. One year later, Graham Bell himself brought to Scotland and exhibited first in Glasgow, and Mr. Preece brought to England, the telephone receiver (then also used as transmitter), almost exactly as it is now constructed. But a vast amount of practical work of a most important kind remained to be done before telephony could be made a commercial success. Without, however, waiting for this to be accomplished, a telephone line was immediately installed by Sir William Thomson between his house at the University and his laboratory, and between both and the workshop of his instrument-maker, Mr. White, in Sauchiehall Street, and this (now merged in the Telephone Exchange) has been in daily use ever since. From this very appropriate first practical beginning has developed the present immense and continually extending system, whose wires form a network above all our great cities, which plays so great a part in the transaction of business, and even of ordinary domestic affairs, and which now enables men in different cities at great distances apart to converse with one another by the living voice. All this has taken place in little more than ten years. Who knows what scientific wonders we may not see before A.D. 1900? But it is mournful to reflect that, as the applications of a scientific principle or invention become more and more wonderful, the thing itself excites so little interest among the people at large who continually use it. This is, no doubt, in part due to our curiosity- and admiration-stifling systems of education, and in part to other causes, about which it is useless to speculate. But true it is, "Familiarity breeds contempt," and, by the ordinary member of the British public, the telephone will soon be as much used, quite as little understood, and regarded with just as little curiosity, as the wonderful machine which he carries in his pocket from his boyhood to the end of his life.

A. GRAY.

OUR BOOK SHELF.

Morocco. By H. M. P. de la Martinière, F.R.G.S. (London: Whittaker and Co., 1889.)

IN this book, which has been translated directly from the author's manuscript, M. de la Martinière records the impressions produced upon him during journeys in the kingdom of Fez, and to the Court of Mulai Hassan. He had exceptional opportunities of making himself acquainted with the facts of social life in Morocco; and in a simple, graphic, and clever narrative he describes exactly what he saw, and the inferences that may be reasonably drawn from his observations. Upon the whole, his account of the condition of the people is most unfavourable, and everyone who studies the evidence he brings forward will admit that the regeneration of Morocco, by whomsoever or in whatever way it may be undertaken, will be no easy task. One of the few bright spots in the author's picture is a passage in which he praises what he calls the refined taste of the Arabs of Morocco. This reveals itself in the industrial products of the country, in the decoration of the pavements and ceilings of their houses, and in the skill with which they match colours in dress. They by no means display the same aptitude for science, which is generally regarded, from a religious point of view, as a forbidden subject. On the other hand, alchemy flourishes, and M. de la Martinière says there are many rogues who trade upon the credulity of the public. Some good route-maps and plans illustrate the text, and a preface is contributed by Colonel Trotter.

LETTERS TO THE EDITOR.

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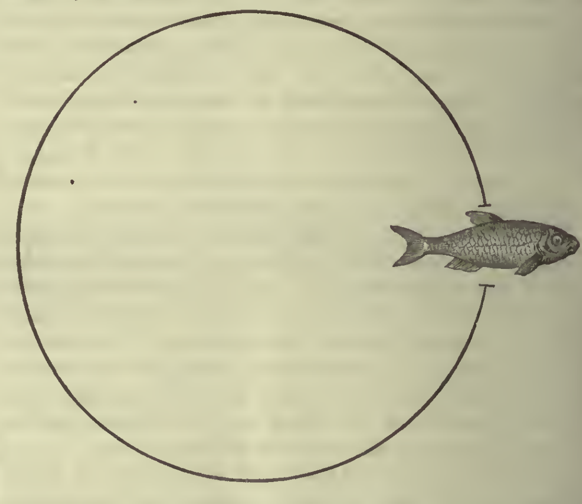
The "Hatchery" of the Sun-fish.

I HAVE thought that an example of the intelligence (instinct?) of a class of fish which has come under my observation during my excursions into the Adirondack region of New York State, might possibly be of interest to your readers, especially as I am not aware that anyone except myself has noticed it, or, at least, has given it publicity.

The female sun-fish (called, I believe, in England, the roach or bream) makes a "hatchery" for her eggs in this wise. Selecting a spot near the banks of the numerous lakes in which this region abounds, and where the water is about 4 inches deep, and still, she builds, with her tail and snout, a circular embankment 3 inches in height and 2 thick. The circle, which is as perfect a one as could be formed with mathematical instruments, is usually a foot and a half in diameter; and at one side of this circular wall an opening is left by the fish of just sufficient width to admit her body, thus:—



The mother sun-fish, having now built or provided her "hatchery," deposits her spawn within the circular inclosure, and mounts guard at the entrance until the fry are hatched out and are sufficiently large to take charge of themselves. As the embankment, moreover, is built up to the surface of the water, no enemy can very easily obtain an entrance within the inclosure from the top; while there being only one entrance, the fish is able, with comparative ease, to keep out all intruders.

I have, as I say, noticed this beautiful instinct of the sun-fish for the perpetuity of her species more particularly in the lakes of this region; but doubtless the same habit is common to these fish in other waters.

WILLIAM L. STONE.

Jersey City Heights, N.J., U.S.A., May 30.

Black Rain.

ON Friday, April 12 last, the rain is stated to have come down black during a thunderstorm at places distributed over a considerable area in the County of Galway, King's County, and County of Tipperary.

I was in England at the time, and after my return to Ireland, on hearing of the rain-water being black in the tanks at a friend's house, I was at first sceptical as to its origin, as a heavy shower after a spell of tolerably dry weather might have brought down much dirt from the roofs, and hence I missed several opportunities of obtaining samples at once.

Finding, however, that other neighbours had noticed the same thing, and that at Golden Grove, near Roscrea, the workmen had observed that not only the water in the barrels was black, and was even next morning "like ink," but also that there was a decided blackness and scum in the pools on the carriage drive, at some distance from any chimney, I was convinced that the blackness had come from the thunder-cloud.

At so great a distance (about 200 miles) from any large smoke-producing town this was somewhat remarkable.

I was able to procure from one place, from near Eyrecourt, Co. Galway, through the kindness of the Rev. C. Lawrence, of Lisreaghan, Eyrecourt, a sample of the water. It is stated to have been of a dark blue colour, but when it reached my hands it had become pale reddish brown, with a considerable amount of solid matter in suspension.

Dr. W. J. Russell, F.R S., has been good enough to examine the sample, which appears to behave in all respects much as London rain water, except in being free from acid reaction (this may be due to previous impurity in the collecting vessel). The amount of sulphates is represented by 0·074 gramme of H_2SO_4, and of chlorides by 0·066 gramme of HCl, in a litre. The solid matter is devoid of structure or of crystalline form, and appears to be soot. The specimen is, however, the less satisfactory from having been taken from near a house where coal has been burnt.

I understand that the rain was black near Shinrone, King's County, and that a few blackish drops were noticed at Dundrum, near Cashel. From Ballymore Castle, near Eyrecourt, where the sample was obtained, to Golden Grove, the distance is about 23 statute miles, and Shinrone is between them. From Eyrecourt to Dundrum is about 48 miles. Mr. Lawrence tells me that the blackness of the rain was noticed by several of his neighbours, and that a laundress kept the water three weeks in the barrels, and had then to reject it, as it was still too much discoloured.

Possibly it may be worth noting that two days before (April 10) there was an intense blackness like that of a moonless night in London, between 12.30 and 1.30 p.m., but I have at present no evidence to connect it with the phenomenon above described.

Athenæum Club, S.W., June 18. ROSSE.

On the Theory of Hail.

IN last week's NATURE (p. 151) Prof. Robinson gives an account of a hailstone that fell at Liverpool on the 2nd instant, consisting of an opaque nucleus, surrounded by almost clear ice, and this by opaque ice.

Hailstones formed of concentric layers, like the coats of an onion, are by no means uncommon. The number of layers has been known to amount to as many as thirteen (*American Journal of Science*, l., 403); but the statement that such a structure is formed, as Prof. Robinson supposes, "during electric oscillation from cloud to cloud," belongs to a theory that has often been disproved. Nor would it probably have excited much attention, but that it originated with no less a man than Volta, who, seeing how pith balls and other light objects oscillated between two metal plates in opposite electrical states, imagined that the hailstone acquired its successive coatings by oscillating between two clouds in opposite states, until its weight became too great for the electric force to sustain it against the gravitating force.

The two most distinguished writers who have examined this theory, and have shown its futility are Kämtz (*Lehrbuch der Meteorologie*, ii. 525) and Becquerel ("Traité de l'Electricité," iv. 151).

The theory of hail which scientific meteorologists now accept, originated with Prof. Olmsted, of Yale College (I have not the reference at hand to the *American Journal of Science*, but see *Edin. New Phil. Journ.*, ix. 244). This theory has received its finishing touches in the papers of the United States Coasts Survey ("Meteorological Researches for the use of the Coast Pilot," Part ii., p. 85, Washington, 1880). The writer is Mr. William Ferrel.

Limiting our notice to such compound hailstones as the one described by Prof. Robinson, which from their size and velocity are the most destructive, and are produced during a tornado or a violent thunderstorm, the following is in few words the theory of their formation. When the wind gyrates rapidly round an axis, more or less inclined to the earth, the space at and about the axis is rarefied. When air charged with vapour is drawn into this rarefied space, it may be condensed into cloud or rain, but at a greater elevation into snow. Now, supposing the rain formed in the lower region to be drawn up by the ascending current into the snowy region, and so held for a short space, the drops will be frozen, and then if propelled beyond the gyrations it will fall to the ground as a shower of ordinary hail. But if in the descent they are again drawn in by the inflowing current, they will be again carried up into the cold region, and so acquire another coating of snow, or, if wetted in the previous descent, the water will freeze into a coat of transparent ice. In this way the globule may make a number of ascents and descents, and acquire a fresh coating each time.

From the date of Franklin's experiments even to our own day, the formation of hail has been attributed to electricity. Even so good an observer as Peltier ("Météorologie," p. 116), while rejecting Volta's theory, offers an electrical theory of his own, with the complacent remark that "Volta a placé des suppositions où je place des faits;" but De la Rive, in noticing Olmsted's theory, very properly remarks that although electricity always accompanies the formation and fall of hail, these two phenomena are not connected as cause and effect.

Highgate, N., June 20. C. TOMLINSON.

Curious Effects of Lightning on a Tree.

DURING the recent thunderstorms a large elm-tree was struck by lightning in a private park at Dulwich, but the only visible effects were linear interrupted grooves about ¾ inch deep, extending down one side of the tree to the ground, where two or three depressions some 3 inches deep were found. The bark is scooped out as clearly as if done with a gouge, and the intervals are from 1 to 2 feet in length, while the grooves themselves are from 1 to 3 feet in length. The grooves are now filled with mildew, which, I take it, indicates the death of the adjacent bark. I have often seen trees which have been struck by lightning, but none in which the effects have at all resembled those I have described. ALFRED S. GUBB.

Gower Street, W.C.

The Formation of Cumuli.

A VERY perfect illustration of the method of formation of cumuli was noted by the writer recently. A perpendicular column of smoke was seen capped at a vast height by a rounded mass of cumulus cloud having a flattened under surface. The ascending warm current being traceable by the smoke, and the cloud-cap very distinct and persistent, the appearance was very striking, the sky in the vicinity being intensely blue and otherwise cloudless. M. A. VEEDER.

Lyons, N.Y., June 10.

Coral Reefs.

THE business of the surveyor abroad is not with theories. It is to collect facts; to apply the resources under his command to the delineation of the earth's surface; and to examine the bottom of the ocean. When he begins to theorize, he may be suspected with some reason of bias, and of insensibly colouring his reports with preconceived notions of what he expected to find, instead of carefully storing up evidence. He is, however, at liberty to study the writings of our great naturalists, and to him Darwin is, at present, the great authority: not so much the young naturalist of the *Beagle*, as the matured thinker who, after forty years of deep research into various problems of Nature, published that edition of "Coral Reefs" which has been before the world for the last fifteen years.

With your permission, I desire to ask two or three questions of those gentlemen who are unable to reconcile their views with Mr. Darwin's theory of subsidence.

The Fiji Islands present the most complete collection of coral reefs in the world. We have there the fringe reef, the barrier, and the atoll; islands which have a barrier all around them, others where it is sunken on one side; the island, such as Lakemba, where there is a fringe on one side and a barrier on the other; as Thithia, which is surrounded by fringe only. There are extinct craters, such as Fulanga, and islands with exterior rim and depression in the centre, the formation of which is apparently not due to the volcanic action; islets on the edge of atolls like Ngele Levu which are wholly coral, others of coral in the centre of lagoons. In the same locality may be found islands which have a fringe to windward and barrier to leeward, and those which have a fringe to leeward and a barrier to windward. One island which is about the size of Jamaica, has a fringe on one side and an extensive barrier on the other. Shells and coral have been found at great heights, and there are many evidences of upheaval. One small island, called Vatu Leile, appears to be raised on one side and depressed on the other; the raised coast is lined with a fringe-reef, the submerged by a barrier.

In the Lau group, there are two fine barrier reefs—those of the Exploring Isles and the Bukatatanoa. Inside the lagoons of these and other reefs, there are an infinity of coral banks with various depths of water over them, many being mushroom-headed.

The prevailing wind throughout the Fiji group is east-south-east. Unquestionably the coral is in most vigorous growth where there is the most violent surf; and no matter what the current, it is in least vigorous growth on the lee or north-west side.

I believe that it is not inconsistent with the theory put forward by Mr. Darwin that, in the same group, some islands should be rising and some falling at the same time; nor that an island should have fallen to a certain level and have then undergone a movement of upheaval. If this be so, there is nothing, as far as one can see, in the Fiji group which disproves subsidence as the origin of barrier reefs. The questions which I desire to ask are these:—

How does Dr. Guppy account for the remarkable similarity in many instances in this group, between the shape of the barrier reef and that of the coast of the island within it? As examples, I would point to the islands of Nairai and Ngau, and to the correspondence in form between the north-east horn of the barrier of the Exploring Isles and the nearest cape of Vanua Mbalavu with its off-lying islets.

In the case of the Bukatatanoa reefs, how does he account for this great rim being all much on the same level, except by the supposition that it commenced its growth on the same contour? or for the cleanly-cut ship channels which occur on the *weather* side of some of the barriers, except by the supposition that the growth was originally checked by the streams from the land?

It is, I believe, universally admitted that there are large areas of elevation—such, for instance, as the New Hebrides—and corresponding areas of depression. What form, does Dr. Guppy suppose, is assumed by the growing coral on the coasts of the descending islands?

Let me draw attention to Kandavu. To the north of this island there is a barrier reef inclosing a chain of islands of volcanic origin, and gradually decreasing height. The most northerly islet, which is a mere rock (now surmounted by a lighthouse), stands in the centre of a circular barrier of great symmetry. The highest part of Kandavu is over the western end, and here there is comparatively little coral. Has not this group every appearance of a range of mountains, the northern half of which is sinking beneath the ocean? There are many strings of islands in Fiji and eleswhere the position and coral surroundings of which seem to be accounted for only by the theory of subsidence.

Mr. Darwin did not visit Fiji; but it is worthy of note that Mr. Dana spent five months there, and enjoyed peculiar advantages of examination, and that he left it convinced of the general truth of Mr. Darwin's theory.

8 Ashburton Road, Southsea. W. USBORNE MOORE.

Hydrophobia.

I THINK it cannot fail to interest some of the readers of NATURE to know what is written "in the Talmud of old—in the legends the Rabbins have told" about this baneful malady. I have therefore translated a fragment preserved in this ancient work, which, read through the mist of ages and wrapped in the garb of expressions and ideas of a long-ago past, may be of value to the antiquarian, and perhaps not wholly uninteresting to the man of science. A. D.

June 11.

"It is not permissible to give to a person bitten by a mad dog from the lobe of the mad dog's liver, but Rabbi Matya, the son of Hheresh, considers it permissible"[1] ("Mishna," "Tractate Yoma," p. 83).

[1] The subject of hydrophobia is introduced quite incidentally, the question in dispute between the "Mishna" and R. Matya being whether the patient might eat of the mad dog's liver upon the fast of the Day of Atonement, and the difference of opinion is in consequence of the prescribed remedy being held to be only imaginary on the one side, and a real one on the part of R. Matya.

"He who is bitten by a mad dog, &c." The Rabannan have learnt that there are five indications of rabies, viz. open mouth, dripping saliva, elongation of ears, tail resting on buttocks, and wandering along the sides of the streets. There are some who add barking without sound. How does this come about? Rav says that witches have practised their sorceries upon them, and Samuel says an evil spirit has rested upon them.

What deduction may be made from this difference of opinion? That the mad dog should be killed by means of a weapon hurled from a distance, for in accordance with the view held by Samuel we learn that the dog, when killed, should be despatched from a distance. He who has come into contact with a mad dog by the animal brushing against him is in danger, and he who has been bitten by a mad dog is in peril of his life.

"He who has come into contact, &c." What precaution should he take? He should divest himself of his robes and *run*. Rav Huna, the son of Rav Joshua, came into collision with a mad dog in the street. He threw off his robes and ran, exclaiming, "I illustrate in my own person the Scriptural verse, 'And wisdom is a source of life to those who possess her.'"

"He who is bitten, &c." What precaution should he adopt? Abaya says he should obtain the skin of a male ape and write thereon, "I, so and so, the son of so and so, write upon thee, 'Kanti, Kanti, Kiloroth,'"[1] and those present should respond "Kandi, Kandi, Kiloroth,[1] the Lord, the Lord, the Lord of Hosts, Amen, Amen, Selah." He should then throw off his clothes and bury them in the burial-place for twelve months, after which he should recover them and burn them in a furnace, scattering the ashes across the roads.

During these twelve months, if he should drink water he should do so only through a copper tube, otherwise he might see the reflection of the demon in the water held in the vessel, and suffer dangerous consequences.

It is said of Aba, the son of Matya (he is Aba, the son of Menimah), that his mother made for him a tube of gold ("Gemara," "Tractate Yoma," p. 84).

SIR LYON PLAYFAIR ON UNIVERSITIES.

WE congratulate Sir Lyon Playfair on the admirable speech he delivered last week in the House of Commons on the Scottish University Bill. It was a powerful and luminous exposition of the true functions of Universities, and of the duty of the State with regard to the highest departments of education.

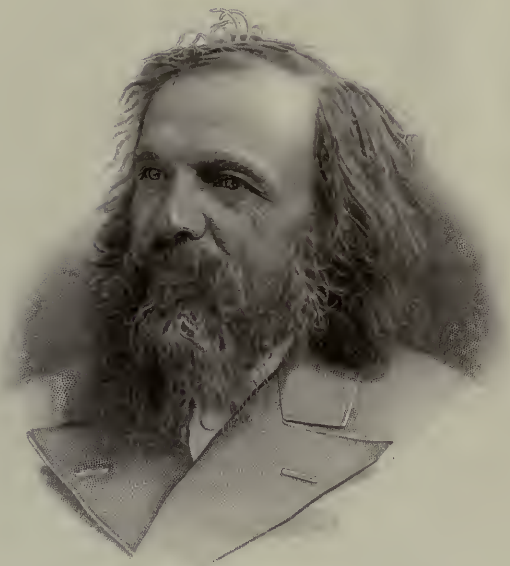
Speaking of the fact that the adaptation of degrees in Scotland had not followed the steady improvement in the education of the people, Sir Lyon Playfair said:—

"Degrees remained much as they were two or three centuries ago. The University was not a technical school, but a school to introduce culture into the professions. Unless that culture were introduced there was no justification for professional schools in the Universities. The *via antiqua* ought to be replaced by a *via moderna*. The Commission of 1878 proposed to open five gateways of knowledge—the gateways of literature and philology, of philosophy, of law and history, of mathematical sciences, and of the natural sciences. Now there was a great difference between the Universities of rich and of poor countries. The Universities of poor countries must rest on the professions. The rich men of Scotland went to Oxford and Cambridge, whereas those who attended the Scotch Universities had to earn their bread by a profession. Unhappily those professions were now being taught without culture; that was, with the exception of theology, the men went through the technical part of their education without taking a degree in arts, though there was a sort of matriculation examination, which did not represent a very high degree of culture. In that way the great medical schools were technical schools which gave length but not breadth of education. One of the greatest reforms to be attained was to carry out the recommendations of 1878 so that, by proper courses in arts, culture might be restored to the professions."

Sir Lyon Playfair spoke as follows about the provision

[1] The meaning of these words is lost.

Nature June 27th 1889



Dmitri Ivanowitsh Mendeleeff.

Engraved by G. J. Stodart from a Photograph by Warwick Brookes

London, Macmillan & C.

made in the Bill for an increase in the vote for the Scottish Universities:—

"The increase of £13,000 in the vote was no striking example of Parliamentary generosity when measured by the efforts of other countries. Reference had been made to what had been done in Holland, a country with a revenue of nine millions, and a population about the same as that of Scotland. Holland gave £136,000 to her Universities. The case of France was equally striking. The French Institute discussed for a whole week why it was that the great crisis in her history produced no men of ability in France. The decision they came to was that the reason was to be found in the decay of the provincial Universities. Since that time the French Government had spent £3,280,000 on the provincial Universities, and voted half a million a year for their support. Then Germany had spent £711,000 in order to build and equip the University of Strasburg, which they endowed with £46,000 a year. This country must be prepared to spend more money on higher education not only in Scotland, but in England. Modest, however, as was the proposal of the Government, he was rejoiced at the disappearance of the abominable finality clause. There was no finality in knowledge or the progress of science. Notwithstanding the stern aspect of the Chancellor of the Exchequer, we could not help ourselves. We must be prepared to adequately support our Universities, and to make sufficient provision for higher teaching in all our great towns. Though he thought the provision inadequate for what the Bill proposed, he had perfect confidence in the generosity of Parliament that, having begun the reform of the Scotch Universities, they would take care that the reform was thoroughgoing. In the Scotch Universities, while the number of students was very large relatively to the number of teachers as compared with, say, the German Universities, they had one Professor for one single subject. For the Chair of Chemistry in Edinburgh, for example—a chair which he had had the honour to hold—there was but one Professor, whereas in any moderate-sized German University there were four or five. They must add largely to the teaching staff of the Universities in Scotland if they expected them to become prosperous. . . . The teaching Universities in England had one student to 3500 of the population; in Ireland there was one student to 2040 of the population; while in Scotland there was one University student to 580 of the population. Therefore, the roots of University education had gone seven times wider and broader among the people of Scotland than they had done either in England or in Ireland. The object had always been to try and evolve brain power from all capable citizens, and it was this which had made Scotland what it was. Nevertheless, it was his deliberate opinion that Scotland was decidedly behind England in education. The English Universities had been adapting themselves to the changing conditions of the world very largely, and the Scottish Universities had been remaining behind in modern wants altogether. The lion rampant in Scotland had been standing on its hind legs pawing the air, while the lion passant with its fore-feet on the ground had been going ahead; and it was because of that consideration that he was extremely anxious to see this Bill pass into law."

THE OXFORD UNIVERSITY OBSERVATORY.

THE Savilian Professor of Astronomy, in his Annual Report, read on June 5, thus refers to the work done:—

In addition to the statutable lectures, four others were given on the recent speculations concerning the construction of the sidereal universe, in relation to possible meteoric collisions.

The renovation of the macro-micrometer, mentioned in the last Report, has been completed by Mr. Simms, who originally constructed it; and it has since been in constant use. The mounting of the De la Rue instrument has been provided with a slow motion in right ascension, of a peculiar and delicate construction, and set in motion by electro-magnets; the driving-clock also has been thoroughly renovated in the parts which exhibited the effects of wear. The object of all these extensive improvements is to make it possible to expose photographic plates during those lengthened periods of several hours, rendered necessary for the purposes of the recent modifications of astronomical inquiries. These improvements have been so recently effected, and the twilight is at present so protracted, that it has not yet been possible to fully test their practical efficiency on the skies.

The mounting of the Grubb equatorial has been completed. It is now furnished with automatic driving apparatus of the most modern and efficient construction, well worthy of the high reputation of its eminent constructor. The visual object-glass has been refigured, and is now in a greatly improved condition. The tube of the photographic telescope is *in situ*, but the object-glass of 13 inches' aperture, meeting the conditions required by the International Congress, has not yet been supplied by the maker. Two experimental object-glasses have, however, been already examined, but their performance did not prove satisfactory. Prof. Pritchard is now expecting the speedy arrival of a third, which, he is assured by Sir Howard Grubb, will relieve him from further anxiety, and place him in a position to prosecute the essential preliminary operations necessary for the International scheme.

All these important renovations and additions, so necessary to practical astronomy in its present phase, have been provided by the unsolicited generosity of the late Dr. De la Rue. Prof. Pritchard expresses deep regret —which he has no doubt is shared by the Board of Visitors—that their lamented and munificent friend did not live, as he had hoped, to see the fulfilment of his anticipations in connection with this judicious expenditure.

The first extensive series of the observations connected with the new application of the photographic method to stellar parallax, as applied to stars of the second magnitude in the northern hemisphere, has been brought to a conclusion, and is now, through the liberality of the Delegates of the University Press, in course of printing. The volume, it is hoped, will be distributed among astronomers in the course of a few weeks. It comprises no less than thirty distinct determinations of stellar parallax: these are applied to eight stars, referred in most cases to four faint stars of comparison. Progress also has been made in the continuation of the like observations to other stars connected with the general scheme. Prof. Pritchard has had the gratification of finding that this method of parallactic determination, which was originally devised at Oxford, is in process of adoption at other well-known Observatories.

At the request of Dr. Gill, he proposes to assist in a scheme of photographic observation of the minor planet Victoria, for the determination of solar parallax during the present summer; efficient assistance, however, can be rendered in this direction only on the condition of the arrival of a satisfactory object-glass from Dublin.

He has been engaged in the examination of a Wedge photometer for the Observatory of Pulkova at the instance of its eminent Director. It is not without some satisfaction that he finds that this method of photometry is likely to be employed in other Observatories.

The Director states that the various operations mentioned above could not have been thus efficiently completed without the continuous and intelligent co-operation of the two able assistants, Mr. W. E. Plummer and Mr. C. A. Jenkins. It has been a source of great gratification to him that Mr. Plummer's ability has been recognized by the Royal Astronomical Society in their selection of him for a seat on their Council.

JOHN PERCY, M.D., F.R.S.

BY the death of Dr. Percy, on the 19th inst, this country has lost a distinguished man, who has greatly influenced its metallurgical progress.

He was born in 1817, and at an early age entered the Medical School of the University of Edinburgh, where, at twenty-one, he took the degree of M.D. He subsequently became Physician to the Queen's Hospital at Birmingham, and the few papers he published on medical subjects show that he would probably have risen to eminence in medicine had it not been for the fact that in the great metallurgical centre of the Midlands his studies were soon diverted to the particular line of work to which his life was ultimately devoted. This is not perhaps surprising when it is remembered that the connection between therapeutics and metallurgy has been traditional since the days of Paracelsus and Agricola.

When we look back at Dr. Percy's career, the remarkable fact stands out that notwithstanding the great importance of metallurgy to this country, with its vast industrial interests, there was no metallurgical treatise worthy of the name until he wrote one; and, what is stranger still, up to the time when he accepted the chair in the Royal School of Mines, in 1851, there was no systematic teaching of metallurgy. Dr. Percy found it practised mainly as an empirical art. Sir Henry de la Beche indicated the direction the teaching had to take, and in his inaugural discourse as Director of the School of Mines, he said, "We still too frequently hear of practical knowledge as if, in a certain sense, it were opposed to a scientific method of accounting for it, and as if experience without scientific knowledge were more trustworthy than the like experience with it." Reference to the pages of the Journal of the Iron and Steel Institute will show that this, the most practical body of men in the world, not only thoroughly recognizes that mere empiricism would be fatal to industrial success, but constantly appeals to science for guidance. This is in great measure owing to Dr. Percy's teaching, and is not the least important of its results.

Ten years after he began to teach, he published the first volume of his treatise on "Metallurgy," which he dedicated with "sincere respect and affectionate regard" to Faraday. This work, which he calls the "task of his life," has developed into a series of volumes containing 3500 octavo pages. One remarkable feature of these books is that almost every woodcut may be regarded as an accurate, though small, mechanical drawing, and it is only measurable drawings of this kind which are of real utility in practice. Treatises such as his naturally embody descriptions of processes furnished by those actually engaged in conducting the operations—aid which was always most fully acknowledged. The thoroughness of his own research is well shown by the careful digests of monographs, which were gathered from all kinds of sources; and it is evident that immense pains were bestowed upon the work. Some years ago a foreign friend, himself a laborious and conscientious author, forcibly expressed to the writer his appreciation of Dr. Percy's labours, looking up from one of the volumes and exclaiming, "*C'est énorme ce qu'il a compilé.*"

It may perhaps be admitted that his intolerance of inaccuracy at times led him to magnify points which now seem to be somewhat trivial, and he sometimes withholds the expression of his own opinion when the reader has fairly a right to expect it, and would be grateful for the support of his authority.

With the notable exception of a process for the extraction of silver from argentiferous ores and residues, he can hardly be said to have originated any important metallurgical process; but his works teem with suggestions, and many improvements in metallurgical practice can be directly traced to his teaching. Such is the case with the practical application of the basic process for eliminating phosphorus in the Bessemer converter—a process of truly national importance, and one which has been widely adopted in other countries. It may fairly be claimed that during the thirty years he held his chair he trained a body of scientific workers in whose hands the immediate future of metallurgy to a great extent rests.

Remarkable evidence as to the strength of his individuality is afforded by the fact that those who were admitted to his friendship, and even his students who only saw him in the lecture-room or laboratory, were all singularly attracted to him, notwithstanding the occasional ruggedness of his manner. The purity of his style and the quaintness of his illustration recall the writings of another doctor, Sir Thomas Browne, making, of course, due allowance for the difference of the periods at which they wrote. The subjects he dealt with were very diverse, and it would be interesting to collect his trenchant letters, which appeared in the *Times*, usually over the signature Y. One especially occurs to the writer. Dr. Percy was charged with the superintendence of the ventilation of the Houses of Parliament, and amusingly describes his difficulties in meeting the varied and often contradictory requirements of the members, as to the temperature best suited to their work. He was an honorary member of the Institution of Civil Engineers, and held the office of President of the Iron and Steel Institute in 1885, having received the Bessemer Medal of that Institute in 1877. His artistic skill was considerable, and he possessed a fine collection of water-colour drawings.

Two days before his death the Prince of Wales awarded him, on the nomination of the Council, the Albert Medal of the Society of Arts. Dr. Percy was still able to appreciate the honour which had been done him, and received the intimation with the characteristic words, almost his last, "My work is done."

W. C. ROBERTS-AUSTEN.

HENRY WILLIAM BRISTOW, F.R.S.

MR. BRISTOW'S death, which we briefly chronicled last week, requires a fuller notice. With him passes away one of the gentlest and most courteous of English geologists—one whose associations connected him with the magnates of geology in the early decades of this century, and whose death breaks another of the links that unite us personally with that heroic time. Born in 1817, he was the only son of Major-General H. Bristow, a distinguished officer, who devoted himself to the cause of Spain, where he died, and received the honours of a public funeral. Mr. Bristow suffered from an inveterate deafness. An old school-fellow, speaking of his boyish days not long ago, remarked that he was as deaf then as he was even late in life. This ailment was undoubtedly a life-long hindrance to him, for it kept him from mingling as freely among his associates, and taking so public a part, as his tastes and abilities would have prompted and fitted him to do.

When twenty-five years of age, he joined the Geological Survey under Sir Henry De la Beche, and he remained in that department of the public service for the long space of forty-six years. Most of his scientific work was done for the Survey, and is to be found in the official maps, sections, and memoirs. It is thus, perhaps, less generally known than that of some of his colleagues who have published communications in the more widely circulated scientific journals. To those, however, who can appreciate accurate and artistic mapping, the work which he did, more particularly among the Secondary rocks of

Dorsetshire and the Isle of Wight, will always possess a special value and charm. It was among the earliest work of its kind, and to this day may be taken as a model of admirable geological cartography. His memoirs, too, are remarkable for their lucidity of statement and clear presentation of fact; also for a certain literary and antiquarian flavour thoroughly characteristic of the author.

In the last fifteen or twenty years of his official life Mr. Bristow's time and thought were mainly given to the duties of administration required by the high appointments to which he was promoted. Under Sir Roderick Murchison he became one of the two district-surveyors charged with the immediate supervision of the field-work in England and Wales, and on the death of that chief and the promotion of Sir Andrew C. Ramsay to succeed him, Mr. Bristow was appointed Senior Director, an office which he held until his retirement last summer.

Yet in spite of the pressure of his official duties, which grew greater as years advanced, Mr. Bristow contrived to find leisure for various pieces of literary work. Perhaps the best known and most useful of them was his "Glossary of Mineralogy,"—a volume which has long been out of print, and in the preparation of a new edition of which he looked forward to employ himself during the present year. He also edited translations of Figuier's "La Terre avant le Déluge" and Simonin's "La Vie souterraine," besides furnishing mineralogical and geological articles to Brande's "Dictionary of Science, Literature, and Art," to Ure's "Dictionary of Arts, Manufactures, and Mines," and to the geological journals. But it is on his contributions to the Geological Survey that his scientific reputation will mainly rest. His last work was the revision of the proof-sheets of a new edition of his classic memoir on the "Geology of the Isle of Wight"—a volume which is now in the press. He did not live to see its publication, and to receive the congratulations of his friends on its appearance as the crowning work of his scientific career. Mr. Bristow has carried with him to the grave the affectionate regrets of his colleagues and of all who ever came in contact with his genial kindly nature.

NOTES.

DR. ARCHIBALD GEIKIE has been elected a corresponding member of the Physical and Mathematical Section of the Royal Academy of Science, Berlin.

ON Thursday last, the 20th inst., a dinner was given in Paris to Prof. Francis Darwin, by the members of Scientia, a group of French men of science, who are accustomed to meet once a month at a friendly dinner, and to invite a distinguished guest of scientific renown. This dinner was the fourteenth since the foundation of the Society, and among the guests have been MM. Pasteur, de Lesseps, Eiffel, Renan, Janssen, Berthelot, and Chevreul. Mr. F. Darwin was the first foreign guest of the Society. The dinner was attended by many eminent scientific men, among whom were MM. Marey, the physiologist, acting President, Eiffel, de Brazza, Richet, de Lesseps, Giard, and some fifty others. Prof. Marey, in very appropriate terms, recalled the great achievements of Charles Darwin, and spoke enthusiastically of the doctrine of evolution—a fact worthy of note, when it is remembered that Prof. Marey is a member of the Institute. Mr. Darwin expressed cordial thanks for the honour conferred upon him, but, in the opinion of most of the members, adopted too modest a tone. His "Life and Correspondence of Charles Darwin" has won for him high rank in the esteem of the French scientific public.

THIS year the summer meeting of the Institution of Mechanical Engineers will be held in Paris. It will begin on Tuesday, July 2. The following papers have been offered for reading and discussion:—Description of the lifts in the Eiffel Tower, by M. A. Ansaloni, of Paris (this paper will be supplemented by results of working to date, communicated verbally by M. Gustave Eiffel, President of the Société des Ingénieurs Civils); the rationalization of Regnault's experiments on steam, by Mr. J. Macfarlane Gray, of London; on warp weaving and knitting without weft, by Mr. Arthur Paget, Vice-President, of Loughborough; on gas-engines, with description of the Simplex engine, by M. Edouard Delamare-Deboutteville, of Rouen; on the compounding of locomotives burning petroleum refuse in Russia, by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-East Russia; description of a machine for making paper bags, by Mr. Job Duerden, of Burnley, communicated through Mr. Henry Chapman, honorary local secretary.

WITH reference to the proposed visit of geologists to the volcanic regions of Italy next October—a scheme to which we referred last week—Dr. J. Foulerton, Secretary of the Geologists' Association, writes to us that the excursion will be under the direction of Dr. H. J. Johnston-Lavis, of Naples, assisted by eminent Italian geologists. Anyone desiring further information on this subject should communicate as early as possible with Dr. Foulerton, at 44 Pembridge Villas, Bayswater, W., sending a stamped and addressed envelope for reply.

AT a meeting on Friday last of the Council of the University College of North Wales, it was decided to open an Agricultural Department at the College in October, and steps were taken with a view to the appointment of a Lecturer in Agriculture. It was stated that the proposal for the formation of dairy schools in connection with the College had met with much support.

FROM the Annual Report of the Principal of the Owens College, Manchester, read on Friday last, at the meeting for the distribution of honours and prizes, it appears that the total number of students has increased during the year from 1269 to 1297, and of these no fewer than 380 are in the Medical School. The number of associates elected during the year was 33: the associates, of whom there are now more than 300 on the roll, are *alumni* of the College, and are only elected after taking a degree at a University. It appears also that during the last year 104 Owens College students passed in arts, science, and law, and 57 in medicine, at the Victoria University. In the London University 51 Owens College students passed in arts, science, and law, and 24 in medicine. Reference was naturally made to the liberal gifts to the College by Sir Joseph Whitworth's legatees. A considerable portion of the most recent extension of the College buildings is devoted to the housing of the old Manchester Natural History and Geological Museums, and the additions made to them since they were handed over to the College. In addition to the sum of £3000 previously given, the Whitworth legatees extended their gift by the further benefactions of £25,000 to the Museum Building Fund, and of £10,000 in augmentation of the Museum Trust Fund.

PRIZES will be distributed at the Medical School, St. Thomas's Hospital, on Tuesday, July 2, at 4 o'clock in the afternoon, by Sir Henry Doulton, almoner of the hospital.

A MEETING of the National Health Society is to be held on Saturday, June 29, in the Town Hall, Westminster, when the Society's certificates gained during the year for proficiency in "domestic hygiene," "sick nursing," and "first aid to the injured," will be presented to the candidates by the Duchess of Westminster.

THE large herbarium of Fungi, transferred by Dr. M. C. Cooke to the Herbarium of the Royal Gardens, Kew, is now for the most part incorporated with the previous collection. The total number of specimens reaches to 46,000, being nearly double that of the Berkeley Herbarium; and these, approximately, represent—

Hymenomycetes	11,000
Gasteromycetes and Myxogastres	2,000
Ustilagines and Uredines	6,000
Discomycetes	6,000
Pyrenomycetes	12,000
Incompletæ...	9,000

The number of species has not been calculated. A large number of these are types, and others as important as types; such, for instance, are the individual specimens used in the illustration of "Mycographia." The entire collection is a most valuable addition to the national collection at Kew, containing as it does contributions from most of the mycologists of the past forty years—Berkeley, Broome, Bloxam, Cesati, Currey, Curtis, De Notaris, Duby, Ellis, Fries, Kalchbrenner, Leveillé, Montagne, Peck, Ravenal, Rabenhorst, Westendorp, Winter, &c., &c.

In a British official Report on Brazil, which has just been laid before Parliament, reference is made to the Pasteur Institute founded at Rio de Janeiro on February 9, 1888. Out of 106 persons treated between then and January 8, 1889, only one died, viz. a child who only attended ten times out of twenty-three attendances ordered. In sixty-two instances the dog biting the people treated at Rio was recognized as undoubtedly mad. Besides the 106 cases, 130 other persons were sent away as having nothing the matter with them.

The National Association for the Promotion of Technical Education has reprinted the excellent series of "Opinions of Practical Men" on the industrial value of technical training, which lately appeared in the *Contemporary Review*. A prefatory note is contributed by Lord Hartington.

We regret to announce the death of Signor G. Cacciatore, Director of the Palermo Observatory. He died on June 16, in his seventy-sixth year.

Prof. Oscar Howard Mitchell, of Marietta College, U.S.A., died at Marietta on March 29, in his thirty-eighth year. Prof. Mitchell did some mathematical work which excited the warm admiration of Prof. Sylvester, whose pupil he had been. Of two papers by him in the *American Journal of Mathematics*, Prof. Sylvester wrote: "I should have been very glad, not to say proud, to have been the author of them."

Early on Saturday morning an earthquake occurred at Watts Town, in the valley of the Little Rhondda. A shock, which was accompanied by a rumbling noise, shook the walls of houses, and caused the inhabitants to run into the streets in alarm. Crockery was broken, and in one instance children were thrown from their beds. At Pontygwaith the shock was severely felt. Mr. Davis, of Penrhys Cottage, says he was alarmed by the noise, and thought it a more than usually violent explosion in one of the collieries which abound in the valley. The walls of his house shook so that he thought the place was coming down, and he ran into the street. The scene in Llewellyn Street was one of the wildest confusion, women and children partly undressed running hither and thither, the greater number of them being of Mr. Davis's opinion that an explosion had occurred. A considerable time elapsed before the people were induced to go back to bed. The weather had been exceedingly sultry for some days.

We learn from the *American Meteorological Journal* that the Chief Signal Officer, Washington, has issued the following instructions relating to weather predictions for two or three days:—"In view of the great importance of long-time weather predictions to the business interests of the country, it is hereby directed that, on and after May 1, 1889, the Indications Official shall make, whenever practicable, a general prediction, showing the condition of the weather two or three days in advance. This class of long-time predictions will be confined to such occasions and such sections of the country as from peculiar and persistent meteorological conditions seem to urge successful forecasts. These predictions will not be too much in detail, but will clearly set forth the section of the country for which they are intended, and the days of the week which they will cover. . . . In making these long-time forecasts, the language should be varied according to the necessities of the occasion, but should always be in such form as to convey clearly to the general public the opinions of the Indications Official, and also the degree of positiveness that attaches to his opinions."

Krüss and Schmidt's statement that both nickel and cobalt contain a small percentage of a hitherto unknown element—gnomium—amounting in the case of one specimen of nickel to as much as 2 per cent. (*Ber. der deut. chem. Gesellsch.*, xxii. 11; Nature, vol. xxxix. p. 325), has not been permitted to pass unchallenged, and quite recently two papers have appeared which tend to show that the supposed new element is non-existent. At the time when they were led to recognize the presence of this common impurity, Krüss and Schmidt were engaged in repeating Winkler's old determination of the atomic weights of nickel and cobalt, in which the ratio Au : Ni or Au : Co was arrived at from the amount of gold precipitated by these metals from neutral solutions of gold chloride. Winkler, in the meantime, has repeated this work with carefully purified materials (*Ber. der deut. chem. Gesellsch.*, xxii. 890), and has not only failed to obtain any evidence of the existence of gnomium, but moreover calls in question the purity of the metallic specimens employed by Krüss and Schmidt. A communication from Dr. Fleitmann to the *Chemiker Zeitung* (xiii. 757) lends considerable support to this view. Adopting the method patented by Krüss and Schmidt for separating this common impurity from nickel and cobalt by extracting the hydroxides of these metals with sodium hydroxide, Fleitmann has examined a number of specimens of commercially pure nickel and cobalt, and, so far from obtaining 2 per cent. of gnomium oxide, has failed to isolate from 50 grammes of material a weighable amount of any impurity which would serve to justify the view that a hitherto unknown element was associated with these metals. Fleitmann points out that when the hydroxides of commercially pure nickel and cobalt are treated with large quantities of sodium hydroxide, impurities go into solution which vary in composition and amount with the source and degree of purity of the metals; these impurities consist of small quantities of the oxides of lead, zinc, arsenic, manganese, molybdenum, silicium, aluminium, cerium, chromium, &c., together with an amount of nickel or cobalt oxide not exceeding 1/20 per cent. of the hydroxide extracted, and when separated from the alkaline solution by the addition of an acid and subsequent precipitation with ammonium carbonate give rise to a highly complex mixture of oxides and acids which can only be separated and identified with considerable difficulty. It is not improbable, therefore, that Krüss and Schmidt have been dealing with some of the constituents of this mixture, and that on further examination gnomium oxide will prove to be a mixture of the oxides of elements already known.

We learn from the *Daily Inter-Ocean*, of Chicago, that Lieutenant Schwatka has reported the discovery of a large tribe of cave-dwellers in the unexplored regions of Northern Mexico. Their abodes are exactly like the old, abandoned cliff-dwellings of Arizona and New Mexico. So wild and timid were the inmates that it was hardly possible to get near them. Upon the approach of white people they usually fly to their caves or cliffs by means of notched sticks placed against the face of the cliffs. They can also ascend perpendicular cliffs without the use of these sticks if there are the slightest crevices for their fingers and toes. A number of children, playing in a deep cañon, were interrupted, and immediately fled to the low brush and rocks and could not be found, hiding as completely as young quail. These cliff-dwellers are usually tall, lean, and well formed, their skin being very blackish-red, much nearer the colour of the negro than the copper-coloured Indian of the United States. They are said to be sun-worshippers.

In response to demand, a new edition of Prof. A. Gray's small work on "Absolute Measurements in Electricity and Magnetism" will be issued immediately by Messrs. Macmillan and Co. The whole work has been very carefully revised, and several alterations and additions made, which it is hoped will bring it into accordance with the present state of practical electricity, and render it still more useful to students and electrical engineers. The preparation of the second volume of the same author's larger treatise on the same subject is being pushed on at the same time as quickly as possible.

Part VI. of the "Catalogue of the Moths of India," by Colonel Swinhoe and Mr. E. C. Cotes, has just been issued. It deals with *Crambites* and *Tortrices*, and there is also a list of "addenda."

The Elizabeth Thompson Science Fund, established by Mrs. Elizabeth Thompson, of Stamford, Connecticut, "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $25,000. The trustees of the Fund have issued a circular, stating that, as accumulated income is again available, they desire to receive applications for "appropriations" in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the trustees to give the preference to those investigations which cannot otherwise be provided for, which have for their object the advancement of human knowledge or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance. Applications for assistance from the Fund, in order to receive consideration, must be accompanied by full information, especially in regard to the following points: (1) precise amount required; (2) exact nature of the investigation proposed; (3) conditions under which the research is to be prosecuted; (4) manner in which the appropriation asked for is to be expended. All applications should be forwarded to the Secretary of the Board of Trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass., U.S.A. It is intended to make new grants at the end of 1889. The trustees are disinclined, for the present, to make any grant exceeding $500; preference will be given to applications for smaller amounts. The following is a list of the grants hitherto made:—(1) $200 to the New England Meteorological Society, for the investigation of cyclonic movements in New England (results published in the *American Meteorological Journal* for 1887 and May 1888); (2) $150 to Mr. Samuel Rideal, of University College, London, England, for investigations on the absorption of heat by odorous gases; (3) $75 to Mr. H. M. Howe, of Boston, Mass., for the investigation of fusible slags of copper and lead smelting; (4) $500 to Prof. J. Rosenthal, of Erlangen, Germany, for investigations on animal heat in health and disease (results published in the *Sitzungsber. k. Akad. Wiss.*, 1888, 1309–19; 1889, 245–254; *Arch. Anat. u. Physiol. Suppl.*, 1888, 1–53); (5) $50 to Mr. Joseph Jastrow, of the Johns Hopkins University, Baltimore, Md., for investigations on the laws of psycho-physics; (6) $200 to the Natural History Society of Montreal, for the investigation of underground temperatures; (7) $210 to Messrs. T. Elster and H. Geitel, of Wolfenbüttel, Germany, for researches on the electrization of gases by glowing bodies (results published in the *Sitzungsber. k. Akad. Wiss. Wien.*, xcvii., Abth. 2, 1175–1264, 1889); (8) $500 to Prof. E. D. Cope, of Philadelphia, Penn., to assist in the preparation of his monograph on American fossil Vertebrates; (10) $125 to Mr. Edw. E. Prince, of St. Andrews, Scotland, for researches on the development and morphology of the limbs of Teleosts; (11) $250 to Mr. Herbert Tomlinson, of University College, England, for researches on the effects of stress and strain on the physical properties of matter; (12) $200 to Prof. Luigi Palmieri, of Naples, Italy, for the construction of an apparatus to be used in researches on atmospheric electricity; (13) $200 to Mr. Wm. H. Edwards, of Coalburg, W. Va., to assist the publication of his work on the butterflies of North America (results published in the "Butterflies of North America," third series, Part 5); (14) $150 to the New England Meteorological Society, for the investigation of cyclonic phenomena in New England; (15) $25 to Prof. A. F. Marion, for researches on the fauna of brackish waters; (16) $300 to Prof. Carl Ludwig, for researches on muscular contraction, to be carried on under his direction by Dr. Paul Starke; (17) $200 to Dr. Paul C. Freer, for the investigation of the chemical constitution of graphitic acid; (18) $300 to Dr. G. Müller, for experiments on the resorption of light by the earth's atmosphere; (19) $300 to Prof. Gerhard Krüss, for the investigation of the elementary constitution of erbium and didymium; (20) $50 to Dr. F. L. Hoorweg, for the investigation of the manner and velocity with which magnetism is propagated along an iron bar; (21) $150 to Mr. W. H. Edwards, to assist the publication of his work on North American butterflies.

The additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Captain M. S. Riach, 79th Highlanders; a Macaque Monkey (*Macacus cynomolgus*) from the Nicobar Islands, presented by Mr. W. J. McCausland; a —— Wild Dog (*Canis* ——) from Bangay, Bornean Group, presented by Mr. C. T. Kettlewell; a Grey Parrot (*Psittacus erithacus*) from West Africa, presented by Miss L. Davy; a Redwing (*Turdus illacus*), British, a Red-legged Partridge (*Caccabis rufa*), European, presented by Mr. J. C. Clayton; a Purple-crested Touracou (*Corythaix porphyreolophus*) from East Africa, presented by Miss Dolly Kirk; two Canary Finches (*Serinus canarius*), three Teneriffe Chaffinches (*Fringilla tintillon*) from Teneriffe, presented by Mr. E. G. Meade Waldo; a Solitary Thrush (*Monticola cyanus*) from Italy, presented by the Rev. H. A. Macpherson; a Common Trumpeter (*Psophia crepitans*) from Demerara, presented by Mr. C. T. Tudway; four Violaceous Night Herons (*Nycticorax violaceus*) from the West Indies, presented by Dr. A. Boon, C.M.Z.S.; an Alexandrine Parrakeet (*Palæornis alexandri*) from India, presented by Miss J. Wilson; two Bolle's Pigeons (*Columba bollii*) from Teneriffe, a Pallas's Sand Grouse (*Syrrhaptes paradoxus*) from Scotland, deposited; a Specious Pigeon (*Columba speciosa*) from Brazil, a Black Francolin (*Francolinus vulgaris*) from India, a Hawk's-billed Turtle (*Chelone imbricata*) from the West Indies, purchased; two Burrhel Wild Sheep (*Ovis burrhel*), a Yak (*Poephagus grunniens*) a Bolle's Pigeon (*Columba bollii*), a Triangular-spotted Pigeon (*Columba guinea*), a Herring Gull (*Larus argentatus*), a Yellow-legged Herring Gull (*Larus cachinnans*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

Recent Determinations of the Amount of Lunar Radiation.—Prof. C. C. Hutchins, formerly of the Johns Hopkins University, now at Bowdoin College, Brunswick, Maine, has recently made some researches in the same field in which Prof. Langley has already worked, viz. the subject of lunar radiation. Prof. Hutchins's first step was the construction of a new form of thermograph, in which a single thermal junction was employed instead of many, the heat rays being condensed upon this one by means of a concave mirror. This combination proved in his hands very successful, though his galvanometer was not the most sensitive possible, since it was a matter of importance that the needle should quickly come to rest. As actually adjusted, the galvanometer gave a deflection of one scale division for 0·00000007 ampere, the period being 10 seconds.

The two principal points to which attention was directed were the comparative intensity of radiation of the sun and moon and the coefficient of transmission of our atmosphere for lunar radiations. The first point was determined by two methods: in one, but a very small fraction of the sun's rays were suffered to fall on the thermograph; whilst in the second method a resistance was interposed in the galvanometer. The two methods gave very fairly accordant results, the mean giving the solar radiation as 184,560 times the lunar. The experiments on the transmission of the lunar rays through our atmosphere gave a remarkably high value: for the deduced result showed that 89¼ per cent. of the rays of the moon when vertical are transmitted by the air at standard pressure.

Observations on the lunar eclipse of January 28, 1888, agreed with those of Langley and Lord Rosse in their testimony as to the suddenness with which the heat received from the moon is cut off at totality.

As to the quality of the lunar rays, it was found that but 31 per cent. were transmitted through a plate of quartz which allowed 93 per cent. of the sun's rays to pass. The radiations from a platinum coil placed in a Bunsen flame turned down as low as possible, suffered to about the same extent as the rays from the moon. From experiments upon the radiating powers of different rocks, a table of which has been formed, Prof. Hutchins concludes that a very considerable portion, about half indeed, of the incident rays are absorbed. The surface of the moon should therefore become strongly heated, but the evidence afforded by total lunar eclipses appears to show that scarcely any of this surface heat succeeds in passing through our atmosphere.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JUNE* 30—*JULY* 6.

(For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on June 30

Sun rises, 3h. 49m.; souths, 12h. 3m. 24·6s.; daily increase of southing, 11·8s.; sets, 20h. 18m.: right asc. on meridian, 6h. 38·4m.; decl. 23° 10′ N. Sidereal Time at Sunset, 14h. 54m.

Moon (at First Quarter on July 6, 6h.) rises, 5h. 35m.; souths, 13h. 48m.; sets, 21h. 54m.: right asc. on meridian, 8h. 22·9m.; decl. 21° 21′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian h. m.	Declination on meridian ° ′
Mercury..	3 14	11 0	18 46	5 35·2	18 47 N.
Venus ...	1 28	8 53	16 18	3 27·8	15 19 N.
Mars ...	3 26	11 48	20 10	6 23·2	24 8 N.
Jupiter ...	19 40	23 34	3 28*	18 11·3	23 16 S.
Saturn ...	7 17	14 48	22 19	9 23·8	16 29 N.
Uranus ...	13 0	18 31	0 2*	13 6·9	6 27 S.
Neptune..	1 43	9 32	17 21	4 6·7	19 16 N.

* Indicates that the setting is that of the following morning.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	July 4	21 46	*m*
U Virginis	12 45·5	6 10 N.	June 30,		*m*
Z Virginis	14 4·4	12 47 S.	July 6,		*M*
U Boötis	14 49·2	18 9 N.	,, 1,		*m*
S Ophiuchi	16 27·9	16 56 S.	,, 1,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 2,	3 11	*m*
			,,	23 19	*m*
X Sagittarii	17 40·6	27 47 S.	June 30,	22 0	*M*
			July 5,	2 0	*m*
W Sagittarii	17 57·9	29 35 S.	,, 1,	0 0	*m*
U Sagittarii	18 25·6	19 12 S.	,, 2,	0 0	*M*
R Lyræ	18 52·0	43 48 N.	,, 6,		*m*
η Aquilæ	19 46·8	0 43 N.	,, 3,	1 0	*m*
X Cygni	20 39·1	35 11 N.	,, 2,	22 0	*m*
T Vulpeculæ	20 46·8	27 50 N.	June 30,	21 0	*M*
δ Cephei	22 25·1	57 51 N.	July 6,	22 0	*m*

M signifies maximum; *m* minimum.

July.	h.	
1	1	Mercury stationary.
1	19	Saturn in conjunction with and 2° 3′ south of the Moon.
1	21	Sun at greatest distance from the Earth.

GEOGRAPHICAL NOTES.

To an unusually crowded meeting of the Royal Geographical Society on Monday night Dr. Frithjof Nansen told in detail the story of his journey across Greenland last summer. We have already given the main incidents of this remarkable journey, and need only refer here to some of the scientific results. These cannot be fully given as yet, as the meteorological and other data collected by Dr. Nansen have not been fully worked out. It should be borne in mind that the main purpose of Dr. Nansen's expedition was to prove that it is quite possible to cross Greenland: in this respect the expedition has been completely successful. Dr. Nansen repudiates as untenable the idea that somewhere in the interior of Greenland an oasis of greenery must exist. The conditions there are quite different from those of Grinnell Land, where the winter's snow is annually melted away over a certain extent of the surface. Greenland, on the contrary, Dr. Nansen maintains, is so thickly covered with the ice-accumulations of ages, that no part of the interior is ever laid bare. He surmises that there is a sort of wind-pole about the high centre of the interior, from which, as a rule, the cold winds radiate in all directions to the warmer coasts. The cold experienced by the expedition reached as low as 90° F. below freezing, and as Dr. Nansen's thermometers were not adapted for a lower temperature he believes that the temperature was at times much under that. He compares the configuration of the inland ice to a shield, curving upwards from the edges to a sort of plateau, reaching in parts at least 10,000 feet above sea-level. As to the configuration of the ground underneath, Dr. Nansen maintains that it must be similar to Norway and Scotland, with the same rugged mountain masses, high ridges, valleys, and fjords; and that the shape of the ice-covering has nothing to do with the shape of the land underneath. The immense accumulation of snow has levelled up everything; in places the ice must be 6000 feet deep, and even the tops of the mountains must be covered with hundreds of feet of glacier. He believes the wind has much to do with maintaining the ice-level, and does not believe that the quantity of snow varies much from year to year. The enormous pressure exercised by this vast mass of ice causes it to send off icebergs, and, in Dr. Nansen's opinion, running water helps to maintain the uniform level. Even in winter, he maintains, there are running streams underneath, due to the action of this pressure, and which help to prevent the growth of the mass. From a meteorological point of view the scientific exploration of Greenland is in Dr. Nansen's estimation of immense importance. He therefore means to return to the country, probably in the autumn of next year. He will land on the east coast, much further north than his last year's starting-point. He will endeavour to explore the east and north coasts, and will attempt to cross the continent at its broadest part.

In illustration of Dr. Nansen's paper a large collection of oil paintings of Greenland scenery was exhibited, by a Danish artist, Mr. Carstensen, who spent two summers and autumns travelling up and down the west coast. They show, better than any photographs, the wonderful colour of the Greenland landscapes, the extent and nature of the ice, and the beauty and richness of the vegetation during the short summer of this ice-bound land.

THE LADIES' CONVERSAZIONE OF THE ROYAL SOCIETY.

The Ladies' *Conversazione* of the Royal Society, given on June 19, was a great success. The following were among the objects exhibited:—

Exhibited by Miss Constance F. Gordon Cumming:—Sketches near the active volcano of Mauna Loa, on the Island of Hawaii, and the extinct crater of Haleakala, on Isle Maui, described in "Fire Fountains of Hawaii."

Exhibited by Prof. Silvanus P. Thompson:—(1) Acoustic apparatus illustrating polarization of light. (2) Magnetic rotation of plane of polarization shown by projecting a polarized beam through a bar of heavy glass, and analyzing by a 24-ray disk of mica, or by a fish-lens. (3) Expansion and contraction, by transverse electrification, of the rings seen in quartz by convergent polarized light. (4) Objects electro-plated with the metal cobalt (new process).

Exhibited by the Hon. Ralph Abercromby:—Photographs and specimen, and map, illustrative of the nitrate of soda industry, and of the nitrate country.—Sun distilling apparatus, on the Atacama desert. This apparatus is situated at Sierra Gorda, near Caracoles, and is the property of Signor Oliveira. It consists of 1875 square feet of glass, something like a row of cucumber frames. A thin layer of salt water is led under the glass, when the heat of the sun vaporizes some of the water, which condenses as a sweat on the under surface of the glass top. The drops gradually coalesce, trickle down into the narrow groove on which the panes of glass rest, and are then led by pipes into a reservoir of fresh water. The bars along the outside of the glass are to save the apparatus from being wrecked by whirlwinds. Rather more water distils by night than by day, owing to the better condensation when the outer air is cool. At the time of my visit the outer air was 97°, the air inside the frames 120°, and that of the salt water inside only 117°, while that of the glass frame itself could not be determined. The apparatus is extremely inefficient, owing to the absence of a proper condenser, and the details are bad; still, from 150 to 175 litres of fresh water are distilled every day, which is sold at a profit for 1½*d.* a gallon. Twenty years ago a similar apparatus, with 50,000 square feet of glass, was erected at Carmen Alto on the same desert, and worked very profitably, as 10*s.* a gallon could then be obtained for fresh water. This apparatus was afterwards wrecked by a whirlwind, and is now replaced by a steam condenser.

Exhibited by Mr. Streeter:—Rubies from the Burmah Mines, English cut and mounted, and in the rough as found.

Exhibited and invented by Mr. Ludwig Mond and Dr. Carl Langer:—New form of gas battery. This battery is an improvement on the well-known gas battery invented by Grove fifty years ago, which produces electricity from hydrogen and oxygen gas by the intervention of platinum. The distinguishing feature of the new battery, which has been designed to obtain large currents of electricity by means of these gases, is that the electrolyte is not employed as a mobile liquid, but in a quasi-solid form, and it is therefore named "dry gas battery." Each element of the battery consists of a porous diaphragm of a non-conducting material—for instance, plaster of Paris—which is impregnated with dilute sulphuric acid. Both sides of this diaphragm are covered with very fine platinum leaf, perforated with very numerous small holes, and over this with a thin film of platinum black. Both these coatings are in contact with frame-works of lead and antimony, insulated one from the other, which conduct the electricity to the poles of each element. A number of these elements are placed side by side, or one above the other, with non-conducting frames intervening, so as to form chambers through which hydrogen gas is passed along one side of the element, and air along the other. One element, with a total effective surface of 774 square centimetres = 120 square inches, which is covered by 1 gramme of platinum black and 0·35 gramme of platinum leaf, shows an electromotive force of very nearly 1 volt when open, and produces a current of 2 amperes and 0·7 volt or 1·4 watt, when the outer resistance is properly adjusted. This current is equal to nearly 50 per cent. of the total energy obtainable from the hydrogen absorbed in the battery. The electromotive force decreases, however, slowly, in consequence of the transport of the sulphuric acid from one side of the diaphragm to the other. In order to counteract this disturbing influence the gases are from time to time interchanged. The battery works equally well with gases containing 30 to 40 per cent. of hydrogen, such as can be obtained by the action of steam or steam and air on coal or coke, if the gases have been sufficiently purified from carbonic oxide and hydrocarbons. The water produced in the battery by the combination of hydrogen and oxygen is carried off by the unconsumed nitrogen and an excess of air carried through it for this purpose.

Exhibited by Messrs. Woodhouse and Rawson, Ltd.:—Samples of copper produced by the Elmore depositing process. Sketches of the appearance under the microscope of ordinary deposited copper, and copper made by the Elmore process. By the Rev. F. Howlett, F.R.A.S.

Exhibited by Prof. J. A. Fleming, D.Sc.:—Edison-Swan incandescence lamps, showing the "Edison effect." If a carbon incandescence lamp has a platinum plate, carried on a wire sealed through the glass, placed between the loop or horse-shoe, it is found that when the lamp is in action a galvanometer connected between the middle plate and the *positive* side of the carbon loop shows a current passing. If the galvanometer is placed between the middle plate and the *negative* side of the loop no current is found. The lamps exhibited show this effect very well. It was first pointed out by Mr. Edison, in 1884. It has been found that shielding the negative leg by a glass or metal tube entirely stops the production of the effect.

Exhibited by the Director of the Royal Gardens, Kew:—Photographs of Ceylon vegetation.

Exhibited by Mr. J. Young:—(1) A cluster of nests of a species of swift (Collocalia) taken in one of the Society Islands. (2) A specimen of *Pluvianellus sociabilis*, a plover obtained in South America, of which only two specimens (obtained fifty years ago) were previously known in Europe. (3) The tail of a Japanese barndoor cock, 11 feet long. (4) Bearded-tits' nest, built in Pampas grass heads, stuck in a flower-pot in an aviary.

Exhibited by Mr. P. L. Sclater, F.R.S.:—(1) Head of Thomson's gazelle (*Gazella thomsoni*), from a specimen shot by Mr. H. C. V. Hunter, in Masai Land, Eastern Africa. This gazelle was discovered by Mr. Joseph Thomson during his expedition through Masai Land in 1883–84, and named after its discoverer by Dr. Günther (*Ann. Nat. Hist.*, ser. 5, vol. xiv. p. 427). (2) Head of Grant's gazelle (*Gazella granti*), from a specimen shot by Mr. Frederick Holmwood, C.B., in the Kilimanjaro district of Eastern Africa. This gazelle was discovered by Colonel Grant, C.B., F.R.S., in Ugogo, in 1860, and named after him by Sir Victor Brooke (P.Z.S., 1872, p. 601). (3) Mummy of a small falcon (probably the kestrel, *Tinnunculus alaudarius*) from the tombs at Thebes in Egypt, obtained from the natives by Mr. A. G. Scott. (4) Tray of birdskins, from St. Lucia, West Indies, collected by Mr. Ramage, the naturalist employed by the joint Committee of the Royal Society and British Association for the exploration of the Lesser Antilles.

Exhibited by Profs. Liveing and Dewar, F.R.S.:—Absorption spectrum of oxygen. The oxygen, compressed to 150 atmospheres, is contained in a steel tube fitted with quartz ends. In the red part of the spectrum are seen the absorptions corresponding to the Fraunhofer groups A and B. Less sharply defined absorption bands are seen in the orange, citron, and blue, and faint bands in the green and indigo. These band absorptions have a totally different character from the great line absorptions of A and B. Beyond the visible spectrum, photographs show some absorptions in the ultra-violet, and the extreme ultra-violet rays are wholly absorbed. This complete absorption extends nearly to the limit of the solar spectrum. This proves that the earth's atmosphere limits the rays which can reach us from the outside. Ozone has even a more powerful absorptive action, and oxygen, ozonized and unozonized, put a limit to our observations of stellar spectra. Profs. Liveing and Dewar have experimented with a steel tube 60 feet in length, and easily capable of holding a mass of oxygen equal to that contained in a vertical column of the earth's atmosphere of equal section.

Exhibited by Mr. Francis Galton, F.R.S:—Reaction-time instrument (working model). The time is measured by a half-second pendulum. The signal is the sharp sound made by a small hammer (noiselessly set free) on its striking a detent, and thereby releasing the pendulum. The response is made by touching a key that releases an arrangement (worked very quickly by a spring) whereby an elastic thread, which is secured above and below to the pendulum, parallel to its rod, but not touching it, is nipped and held fast against a horizontal bar. The bar is graduated to hundredths of a second, so that the graduation opposite to the thread shows the elapsed time between the signal and the response. The pendulum receives no jar, and continues to vibrate.

Exhibited by the Hon. A. Holland-Hibbert:—(1) Old telescope, with parchment tubes. (2) Old microscope, of stamped leather. Both formerly the property of King Charles I.

Exhibited by Mr. Fred. Enock:—Microscopical preparations illustrating the life-history of the Hessian fly (*Cecidomyia destructor*, Say).

Exhibited by Mr. Percy E. Newberry, by kind permission of the Director of the Royal Gardens, Kew:—A series of ancient funeral wreaths and plant remains, discovered last year by Mr. W. M. Flinders Petrie, in the cemetery of Hawara, Egypt. (I.) The wreaths, which are of Egyptian and Greek manufacture, were all made in the first century B.C., and were found in wooden coffins, either resting on the heads or surrounding the bodies of the mummies. Among them the following are of special interest:—(1) A very perfect wreath composed of the flowerheads of a species of Immortelle (*Gnaphatium luteo-album*, L.), called by the ancients "helichrysos," and much used by them in making garlands. Helichrysos wreaths are mentioned by Pliny ("Hist. Nat.," xxi. 96) as having been used in Egypt in Ptolemaic times, also by Theophrastus, Athenæus, Cratinus, &c. (2) Portion of a curious garland made of cones of papyrus pith, lychnis and rose flowers, rose petals, and scarlet berries of the woody nightshade. These latter are mentioned by Pliny as having been employed in garland-making by the Egyptians. (3) Portion of a wreath (of Greek manufacture) made of flowers of the Polyanthus Narcissus (*N. Tazetta*, L.). Wreaths made of this flower, the "clustered Narcissus" of the ancients, are often mentioned by early Greek poets. Sophocles thus alludes to them:—

θάλλει δ' οὐρανίας ὑπ' ἄχνας
ὁ καλλίβοτρος κατ' ἦμαρ ἀεὶ
νάρκισσος, μεγάλαιν θεαῖν
ἀρχαῖον στεφάνωμα.—*Œdipus Coloneus.*

(4) Portion of a wreath made of the flowers of a species of rose (*Rosa sancta*, Richards). (5) A perfect wreath composed of rose petals threaded by a needle on to strips of twine. "Recently," writes Pliny in his history of garlands, "the rose chaplet has been adopted, and luxury has now arisen to such a pitch that rose garlands are held in no esteem at all if they do not consist entirely of petals sewn together with the needle" ("Hist. Nat.," xxi. 8). There are also exhibited: (6) a portion of a wreath composed of twigs of sweet marjoram (*Origanum Majorana*, L.), lychnis flowers, coils of papyrus pith, and pieces of copper tinsel; (7) a portion of a wreath composed of chrysanthemum flowers and leaves, purple cornflowers, and petals of the flower of a species of *Hibiscus*; (8) a portion of a wreath made of flowers of *Matthiola Librator*, L., flowers of the polyanthus, narcissus, and *Hibiscus* petals; (9) portions of two necklaces made of flowers of the date palm threaded on strips of twine; and (10) a fragment of a necklace made of fruits of the date palm. (II.) Among the plant remains are peach stones, dates, and date stones, walnut shells, currants, pomegranates, plums, figs, chick peas, common garden beans and peas, lentils, wheat, barley, and oats. These are probably the remains of the ancient funeral feasts which were held in the Hawara Cemetery by the relatives of the deceased people who were buried there. The whole collection (of which the series here exhibited is only the third part) is fully described by Mr. Percy E. Newberry in Mr. Flinders Petrie's "Hawara, Biahmu, and Arsinoe."

Exhibited by Dr. H. H. Hoffert:—Photograph of lightning flashes taken at Ealing, on June 6, 1889.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Harkness Scholarship, for Geology and Palæontology, has been awarded to T. T. Groom, Scholar of St. John's College.

Mr. J. T. Nicolson, B.Sc. of Edinburgh University, has been appointed Demonstrator in Mechanism and Applied Mechanics.

The Mechanical Workshops Syndicate reports that the practical instruction in engineering and mechanism is producing excellent results in the training of engineers, but that the subject suffers by the lack of a higher technical examination analogous to a tripos, while the workshops do not get all the work they might do, owing to the withdrawal of the University Museums' work.

An examination for Scholarships in mathematics and in chemistry and physics will be held at Peterhouse on October 15. A syllabus of subjects may be obtained from the tutor.

The local lectures in science have been largely attended during the past year; the largest audiences being at Kettering, where astronomy was the subject, and Mr. J. D. McClure the lecturer, and at Lancaster, where Mr. E. A. Parkyn lectured on human physiology.

The Students' Associations have made good progress in many localities, and in Surrey a student, Mr. Broderick, of Guildford, was found sufficiently qualified to repeat the courses in several villages with much success.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 6.—"Notes on the Absorption-Spectra of Oxygen and some of its Compounds." By Profs. Liveing and Dewar.

The authors give a diagram representing the absorption, both in the visible and in the ultra-violet parts of the spectrum, of 18 metres of ordinary oxygen gas at a pressure of about 97 atmospheres—that is, of a mass of oxygen rather greater than is contained in a vertical column of equal section of the earth's atmosphere. Under the circumstances of the experiment the absorptions A and B are very black, and the lines of which they are composed appear much broader than in the ordinary solar spectrum. The other bands are all diffuse at their edges, and, so far as observed, unresolvable into lines. The complete absorption of the ultra-violet rays does not extend quite so far down as the limit of the solar spectrum, though it approaches that limit. There is a diffuse edge of gradually diminishing absorption succeeding the complete absorption, and this fact, together with the rapid diminution of the extent of the complete absorption with decrease of pressure, lead the authors to class this absorption of the extreme rays with the diffuse bands, which, according to Janssen, increase in intensity as the square of the density of the gas. If that be so, it is unlikely that the limit of the solar spectrum is due to the absorption of ordinary oxygen. For though we may suppose interplanetary space to be pervaded by materials similar to our atmosphere, yet they must be in such a state of tenuity that, although they may to some extent reinforce A and B, they will not add sensibly to the strength of the diffuse bands. Moreover, these bands, though identical in position, so far as the blue and less refrangible part of the spectrum is concerned, with bands observed by Brewster and others in the solar spectrum, are seen much more strongly through tubes of compressed oxygen than they appear in the solar spectrum with a low sun. The ultra-violet bands, of which the one near N appears in photographs nearly as strong as the band just above F, and that in the indigo, have not, so far as the authors are aware, been noticed in the solar spectrum. Probably they would appear if photographs were taken with small dispersion when the sun was low.

As the pressure in the tube diminished, the bands rapidly faded; that in the indigo, with an oscillation-frequency or wave number about 2240, was the first to disappear, then those near L and O and that near E. At the same time the limit of the transmitted ultra-violet light advanced from an oscillation-frequency of about 3575 at 97 atmospheres, to 3710 at 50 atmospheres and 3848 at 23 atmospheres. At 20 atmospheres the three bands above C, D, and F, respectively, were still visible, though faint. B remained visible until the pressure was reduced to 2 atmospheres, and A could still be seen, but with difficulty, when the pressure of the 18 metres of oxygen was reduced to 1 atmosphere.

When atmospheric air was substituted for oxygen the authors found that 7 atmospheres was the limit of pressure at which they could certainly distinguish A, and 18 atmospheres the limit at which they could see B. It is a difficult matter to say exactly when an absorption becomes invisible, but the observations on air were made under the same circumstances as those on oxygen, and the two sets of observations were fairly comparable. With air at 75 atmospheres the three bands above C, D, and F, respectively, could all be seen, but that near C only with difficulty. The mass of oxygen and its *partial* pressure in the tube was in this case less by about one-quarter than that which was required to bring out the bands when oxygen alone was used. The cause of this may be that the development of the diffuse bands depends in some degree on the total pressure of the air, and not only on the partial pressure of the oxygen in it.

The mass of oxygen which when unmixed with nitrogen made A visible would correspond to that in the tube filled with air at 5 atmospheres, and that which made B visible would correspond to air at 10 atmospheres. The differences between these pressures and those which are actually needed to render A and B visible seem too great to be ascribed to errors of observation, and seem to indicate that the addition of the nitrogen has some effect on the absorptive action of the oxygen. On the other hand, Egoroff found that he could still distinguish A when the thickness of air at ordinary pressure was reduced to 80 metres (*Compt. Rend.*, vol. ci. p. 1144). This amount of air corresponds to rather less oxygen than the 18-metre tube would hold at a pressure of 1 atmosphere. Differences in the sources of light, in the spectroscope, and the observers, would, however, count for a good deal in observations of this kind.

In order to try the influence of temperature on the absorption, the shorter of the experimental tubes, 165 cm. long, was surrounded by a jacket filled with a mixture of solid carbonic anhydride and ether, which was rapidly evaporated by means of a large air-pump. By this means the temperature would be reduced to – 100°. The absorption of oxygen at several different pressures up to 104 atmospheres was observed through the cooled tube. The authors were not, however, able to detect any increase of intensity, or other change, in the absorptions which could be ascribed to the cooling. To try the effect of an increase of temperature, the 18-metre tube was surrounded by a jacket and heated up to 100° by steam. Heating appeared to render the diffuse bands rather more diffuse and less distinct. On the whole the influence of a change of temperature of 100° either way is slight.

The authors have observed repeatedly the absorption of liquid oxygen in thicknesses of 8 and 12 mm. Their observations confirm those of Olszewski. 8 mm. of liquid oxygen gives plainly the three diffuse bands above C, D, and F, respectively. With a thickness of 12 mm. the authors were not able to detect any more.

The authors observed the absorption produced by liquid oxygen on the one hand when it was cooled by its own evaporation until the tension of its vapour was only equal to that of the atmosphere—that is, to a temperature of – 181°, according to Olszewski—and also when the temperature of the liquid was allowed to rise under pressure up to nearly the critical temperature. There appeared to be no appreciable difference in the absorption under these different circumstances when the oxygen was completely liquid, when it was near its critical temperature, and when it was completely gaseous; so far at least as concerns the three principal bands, which were all that could be seen in the light transmitted by the liquid in a thickness of 12 mm.

It will be observed that taking the density of oxygen at – 181°·4 to be 1·124, as given by Olszewski, 12 mm. of the liquid would be equivalent to 9·37 metres of the gas at atmospheric pressure—hardly more than half the thickness required to make A visible. The experiments, therefore, point to the conclusion that gaseous and liquid oxygen have the same absorption-spectrum. This is a very noteworthy conclusion. For, considering that no compound of oxygen, so far as is known, gives the absorptions of oxygen, the persistency of the absorptions of oxygen through the stages of condensation to the state of complete liquidity implies a persistency of molecular constitution which we should hardly have expected.

In order to compare the absorption of ozone with that of oxygen, the authors employed a tube 12 feet long, made of tinplate fitted with glass ends and coated with paraffin on the inside. Ozonized oxygen was passed into the tin tube for some time, while the ozonizer and the tube itself were cooled with ice and salt. The lime-light, viewed through the tube, looked very blue, and also the spot of light thrown from the tube on to a sheet of white paper was equally blue, indicating a considerable absorption of the less refrangible part of the spectrum. The absorption, so far as the visible rays are concerned, appeared to be of a general character, for the spectroscope revealed only four extremely faint absorption-bands. The centres of these bands were at about the wave-numbers 1662, 1752, 1880, and 1990, and their positions with reference to the bands of oxygen are indicated in the diagram. They were so faint as to be seen only with difficulty. When the hot carbon of an arc lamp was substituted for the lime-light they were rather more distinct, but the positions of the edges were undefinable. The light of a gas-lamp was insufficient to show them, and they were no better seen with a single-prism spectroscope of low dispersive power than with the spectroscope employed for observing the oxygen. Only one of these bands is nearly coincident with an oxygen-band—namely, that near E, the faintest of the oxygen-bands. That at wave-number 1752 overlaps the strongest oxygen-band, but not at its strongest part, and has none of the peculiar character of its shading, abruptly increasing on the less refrangible side and slowly decreasing on the other side. Photographs of the spectrum (taken through a tube with quartz ends) showed that the ozone absorbed all the rays above the wave-number 3086—a point between Q and R—while partial absorption extended below Q. It may be said, therefore, that no identity can be traced between the absorptions of ozone and those of ordinary oxygen. There is no mere displacement of the bands, such as sometimes occurs when a coloured substance is dissolved in different menstrua, nor any such resemblance as subsists between the absorption-bands of the different cobaltous salts derived from different acids.

The four bands which are seen to be produced by ozonized oxygen correspond fairly with the second, third, fifth, and sixth of the bands described by Chappuis as due to ozone (*Annales de l'Ecole Normale*, 2nd ser., vol. xi., May 1882). These four bands, he says, are the first to be seen. The authors have failed to perceive any others with the 3·66 m. tube, though the oxygen was highly ozonized, and maintained at a low temperature. None of the bands were of sufficient intensity to make themselves visible on photographic plates.

It will be noted that the absorption by ozone extends far below the limit of the solar spectrum. By diminishing the proportion of ozone to oxygen in the tube the limit of the transmitted light was continually advanced, as already described by Hartley. The limit of the solar spectrum may, therefore, very well be determined by the average amount of ozone in the atmosphere, as Hartley supposes. The known variations in the limit of the solar spectrum may be taken as confirmatory of this hypothesis, although the comparatively small amount of those variations is certainly less than we should have expected if they measure the changes in the proportion of ozone in the atmosphere.

The absorptions of the class to which A and B belong must be those which are most easily assumed by the diatomic molecules (O_2) of ordinary oxygen. Whether oxygen in more complex molecules, as in ozone (O_3), may be capable of taking up the corresponding vibrations cannot easily be determined, because we cannot isolate ozone; but since none of the compounds of oxygen with nitrogen, hydrogen, or carbon, or, so far as known, with any other element, exhibit these absorptions, it is very probable that they are peculiar to the molecule O_2. From this point of view it will be interesting to determine whether liquefied oxygen, which we suppose to have more complex molecules, produces these absorptions The corresponding spectrum of emission has not as yet been observed, probably because the agency employed to render the gas luminous breaks up the molecules into single atoms of oxygen.

As for the other class of absorption, the diffuse bands, since they appear to have intensities proportional to the square of the density of the gas, they must depend on a change produced by compression. This may either be the formation of more complex molecules, as for example O_4, corresponding to the deviation from Boyle's law exhibited by oxygen gas, or it may be the constraint to which the molecules are subject during their encounters with one another. Increase of temperature would affect the former, tending to diminish the number of complex molecules formed at a given pressure, but would have no effect on the latter, for though the number of encounters of the molecules in a given interval of time would be greater the higher the temperature, yet so long as the volume was unaltered the ratio of the duration of an encounter to that of free motion would be sensibly unaltered. So far as any change due to temperature has been observed, it is that a rise of temperature slightly weakens the diffuse absorptions.

Reverting to the compounds of oxygen, none of them show the absorptions of oxygen, not even the general absorption of the ultra-violet rays. Some of them, such as water and carbon dioxide, appear quite transparent to ultra-violet rays, while in others, such as nitrous oxide, which show a general absorption of the ultra-violet rays, the limit of transparency is different from that of oxygen. In other respects we may say that there is no resemblance between the absorptions of the compounds of oxygen and those due to oxygen itself. Some of the former have very definite and characteristic absorptions, such as the well-known spectra of the peroxides of nitrogen and chlorine, and we must regard these as indicating the rates of vibration which the molecules NO_2 and ClO_2 respectively are capable of easily taking up. The absence of the absorptions due to oxygen from all compounds of oxygen seems to indicate either that chemical combination is not, as has been supposed by some chemists, a temporary relation in which the molecular groupings are continually breaking up, to be formed anew with ever-changing elementary atoms; or, that the periods of dissociation are very small compared with the periods of association. For otherwise we should expect that such compounds of oxygen as CO_2 and NO_2 must always have amongst their molecules some molecules identical with those of oxygen and capable of taking up vibrations of the same period. At least we must conclude that little, if any, of the oxygen of these and other compounds is ever out of the influence of the other components.

The authors have re-examined the absorption-spectrum of N_2O_4 at various temperatures, and agree with the conclusions of Bell (*Amer. Chem. Journ.*, vol. vii. p. 32), that N_2O_4, whether liquid or gaseous, effects only a general absorption at either end of the spectrum, and that the selective absorptions observed with it are due to the presence of NO_2.

In order to obtain pure N_2O_4, the tube in which the liquid was sealed was placed in a freezing mixture, and a large part of the liquid frozen; the remaining liquid was then drained as completely as possible into the other end of the tube, and sealed off.

It should be observed that the crystals of N_2O_4 appear colourless, and that when they are melted the liquid and superincumbent vapour are of a very pale yellow colour. As the temperature rises, both liquid and vapour become, as is well known, of a deep orange, and finally of a dark, reddish-brown colour. The authors examined the spectra produced by two thicknesses of liquid and vapour—(1) by that contained in a narrow tube about 1 mm. in diameter, and (2) by that in a tube about 1 cm. in diameter. At 15° to 20° the vapour in the narrow as well as in the wider tube showed the well-known absorption-spectrum of fine, dark lines; no absorption by the liquid in the narrow tube could be detected, and the liquid in the wide tube showed no fine lines, but several faint, very diffuse bands, unresolvable into lines with a spectroscope of three prisms. These bands had their maxima in places where the fine lines of the vapour were most intense and most closely set, so that it might be inferred that they were due to similar molecules in both cases, but that in the liquid the vibrations of these molecules were no longer sharply defined, but modified by the constraint arising from the liquid state. Some parts, however, of the spectrum of the vapour, where the lines were closely set, did not appear to be represented by any definite bands in the liquid. The liquid absorbed a good deal of blue light in a continuous manner, while the vapour only absorbed it selectively. At the red end the limit of the visible spectrum was lower for the liquid than for the gas—that is, there was more absorption of red light by the vapour than by the liquid, so much so that below a certain point the absorption by the vapour appeared continuous.

The narrow tube was next immersed in a wider tube full of glycerine, which was gradually heated. As the temperature rose, the colour of both liquid and vapour deepened, the absorptions of the vapour were stronger, and the liquid gave the same bands as had been before observed with the greater thickness. At still higher temperature the absorption of blue light, both by liquid and vapour, diminished sensibly, until at 85° the groups of lines in the blue had pretty well disappeared from the spectrum of the vapour. In fact, at 85° there was no sensible difference between the actions of liquid and vapour on blue light, it seemed only some continuous absorption. At the red end the difference between the liquid and vapour remained quite as strongly marked as at lower temperatures—if anything, more so; and the absorptions in the orange, yellow, and green were unaltered. At 90° the lines of the vapour in the green began to fade, and at 100° they were very faint; but those in the orange, as well as the corresponding diffuse bands in the liquid, were as strong as before. There was still considerably more absorption of red light by the vapour than by the liquid, as if there were a strong absorption-band in the red of the vapour which was absent in the liquid.

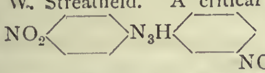
As the temperature rose to 110° all the lines in the vapour had become faint, and at 115° they were no longer discernible, and there was no difference between the spectra of liquid and vapour except in the red, and even here the difference was less marked than at lower temperatures. At 130° no distinction was observable between the spectra of liquid and vapour; there were no lines or bands in either, but a good deal of general absorption. Liquid and vapour were dark, and appeared much of a colour, but the meniscus at the junction was quite evident. The tube was further heated to 155°, but no further change was noticed in the spectrum. On gradually cooling the tube, at 112° the least refrangible band in the orange was seen coming in both in vapour and liquid, diffuse in both. At 100° the usual lines were well seen in the orange, yellow, and citron of the vapour, faint lines in the green, and none in the blue; and subsequently the appearances presented on heating followed in the reverse order.

A solution of N_2O_4 in carbon bisulphide gave, in a thickness of 7 or 8 cm., diffuse absorption-bands in the green and citron, ill-defined as in liquid N_2O_4 and in corresponding positions. In a thickness of 1 cm. these bands were no longer visible.

These observations bear out the supposition that pure N_2O_4 is without selective absorption of the visible rays, and that the absorption observed is due to NO_2, both in the vapour and liquid, this absorption being modified in the liquid by the state of solution in which the molecules have much less freedom. As the temperature rises, the proportion of NO_2 increases, and at the same time the density of the vapour increases and the freedom of motion of the molecules is diminished, they are less able to assume the more rapid vibrations, and those which they do assume become less sharply defined, so that the lines fade into bands and ultimately into a general absorption.

Chemical Society, June 4.—Dr. W. J. Russell, F.R.S., President, in the chair.—Prof. Mendeleeff's Faraday Lecture on the periodic law of the chemical elements, was read by the Secretary, owing to the enforced absence of the lecturer. At the conclusion of the lecture, a vote of thanks to Prof. Mendeleeff was moved by Prof. Frankland, and seconded by Sir F. A. Abel. The Faraday Medal and a purse were then presented by the President to Mr. Anderson, by whom it was received on behalf of Prof. Mendeleeff.

June 6.—Dr. W. J. Russell, President, in the chair.—The following papers were read:—Experimental researches on the periodic law, Part I., by Dr. B. Brauner. The author gives a detailed account of his attempts to determine the atomic weight of tellurium by as many different methods as possible; in all, eleven were adopted, but each gave a different result, varying from 125–140. He eventually succeeded, but with great difficulty, in preparing what appeared to be pure tellurium tetrabromide, and on most carefully analyzing this, obtained the value Te = 127·64 (O = 16). This number, however, is incompatible with the position of tellurium in the periodic system, and having satisfied himself that there were no experimental errors which could account for the discrepancy, the author was forced to conclude that what had hitherto been regarded as pure tellurium contained foreign elements. By submitting tellurium solutions to a systematic fractional precipitation, he has, in fact, succeeded in obtaining a variety of substances, some of which are undoubtedly novel elements. One of these it is proposed to call *Austriacum* (*Austrium*). In all probability this is the *Dvi-tellurium* (212), the probable existence of which was pointed out for the first time by Mendeleeff in his recent Faraday Lecture. From analyses made with material the uniformity of which is not yet quite established, the author is satisfied that the atomic weight of the element in question approaches very closely to that indicated by Mendeleeff. In addition, there is at least one other novel constituent, and this appears to be more or less closely allied to arsenic and antimony. It follows that true tellurium has yet to be discovered, and that its atomic weight and properties remain to be determined.—The amylo-dextrin of W. Nägeli, and its relation to soluble starch, by Mr. H. T. Brown and Dr. G. H. Morris. Amylo-dextrin, described by W. Nägeli in 1874, is prepared by the long-continued action of cold dilute acids on intact starch granules; when purified by dissolution in water and precipitation with alcohol, it forms crystalline spherules, closely resembling those of inulin. The authors consider amylo-dextrin to be analogous in composition to the malto-dextrin previously described by them (Chem. Soc. Trans., 1885, 528), and assign to it the formula $C_{12}H_{22}O_{11} + (C_{12}H_{20}O_{10})_6$; *i.e.* it may be regarded as constituted of one amylon or maltose group in combination with six amylin or dextrin groups. Soluble starch, with which amylo-dextrin has frequently been confused, is converted into a mixture of maltose and dextrin on treatment with diastase, whilst amylo-dextrin yields maltose exclusively; moreover it is shown that soluble starch is the first product of the action of cold dilute acids on starch, and that this is slowly hydrolyzed to amylo-dextrin, a portion of the starch substance at the same time going into solution as dextrose.—The determination of the molecular weights of the carbohydrates Part II., by the same. As determined by Raoult's method, galactose and malto-dextrin are found to have molecular weights corresponding with the formulæ $C_6H_{12}O_6$ and $C_{12}H_{22}O_{11} \cdot (C_{12}H_{20}O_{10})_2$ respectively. For inulin the formula $2(C_{36}H_{62}O_{31})$ is deduced, and in view of the great similarity in physical properties between inulin and amylo-dextrin the authors are inclined to regard the two substances as closely analogous in composition, representing inulin by the formula $(C_{12}H_{22}O_{11})_2 +$

$(C_{12}H_{20}O_{10})_4$, although the amylon and amylin groups in each possess very different optical and other properties, and the products of the hydrolysis with dilute acid are very different. It was found impossible to apply Raoult's method to starch-paste; solutions of soluble starch produced so slight a depression that no reliable results can be obtained; a number of fairly concordant results, however, pointed to a molecular weight of 20,000 to 30,000. In order to ascertain whether the failure in this case was due to a high molecular weight, and not to the fact that the method was inapplicable to colloid substances, an arabinic acid, having a rotatory power $[\alpha]_j = + 61^{\circ} \cdot 16$, was examined; this gave a molecular weight of 717, thus rendering it probable that the small influence exercised by soluble starch was due to its high molecular weight. Indirect evidence was then sought for by an examination of the dextrins. The authors have previously shown that when starch is broken down by diastase, a resting stage in the reaction is reached when the amount of dextrin produced corresponds with one-fifth by weight of the starch taken, and that the molecule of this stable dextrin is one-fifth of the size of the starch-molecule from which it has been derived. Determinations of the molecular weight of this low dextrin pointed to the formula $20C_{12}H_{20}O_{11}$, and consequently the formula of soluble starch would be $5(C_{12}H_{20}O_{10})_{20}$, and its molecular weight 32,400. The endeavour was also made to apply Raoult's method to the determination of the question whether the dextrins are a series of polymers or whether they are simply metameric. For this purpose a number of the higher dextrins were prepared from starch-transformations which had been stopped at an early stage of hydrolysis. All the numbers obtained show that the freezing method affords no evidence of there being any difference in molecular weight between the high and low dextrins, the numbers being, in fact, almost identical. From a consideration of the results obtained with soluble starch, and with dextrins of varying position in the series, the authors conclude that the evidence points to the conclusion that the dextrins are metameric and not polymeric compounds. They therefore abandon their former working hypothesis of the hydrolysis of starch, and now suppose the starch-molecule to consist of four complex amylin-groups, arranged round a fifth similar group constituting a molecular nucleus. When hydrolysis takes place this complex is broken up, four amylin-groups being liberated, which in turn are capable of undergoing complete hydrolysis into malto-dextrins, and ultimately into maltose, whilst the fifth amylin-group which constituted the nucleus of the original molecule resists the action of hydrolyzing agents, and forms the stable dextrin of the No. 8 equation of the authors' previous papers (Chem. Soc. Trans., 1879, 634; 1885, 539). Each amylin group of the five has the formula $(C_{12}H_{20}O_{10})_{20}$, corresponding with a molecular weight of 6480; the molecule of soluble starch being represented by $5(C_{12}H_{20}O_{10})_{20}$, corresponding with a molecular weight of 32,400.—Researches on silicon compounds, Part V., by Prof. J. E. Reynolds.—The isomerism of the alkyl-derivatives of mixed diazoamido-compounds, by Prof. R. Meldola and Mr. F. W. Streatfield. A critical study of the mixed diazo-amide, , has served to confirm the conclusion arrived at by the authors in their previous communications (Chem. Soc. Trans., 1886, 624; 1887, 102, 434; 1888, 664), that this compound and its alkyl-derivatives are perfectly definite, and that they cannot be formed by crystallizing together mixtures of the corresponding symmetrical di-meta- and di-para compounds. The authors restate their original proposition, viz. that every pair of amines, $X.NH_2$ and $Y.NH_2$, can give rise to three isomeric alkyl-derivatives—(1) by the action of diazotized $X.NH_2$ on $Y.NHR'$; (2) by the action of diazotized $Y.NH_2$ on $X.NHR'$; (3) by the direct alkylation of $X.N_3H.Y$. In support of the general truth of this proposition a large number of triplets have been prepared, all of which conform to the rule laid down. The isomerism of these triplets is shown not only by their melting points, but also by their products of decomposition by cold hydrochloric acid. These products have in all cases been examined quantitatively, and the general results are shown by the equations—(1) $X.N_2.NR'.Y + HCl = X.N_2.Cl + Y.NHR'$; (2) $Y.N_2.NR'X + HCl = Y.N_2.Cl + X.NHR'$; (3) $2X.N_3R'.Y + 2HCl = X.N_2Cl + Y.N_2.Cl + X.NHR' + Y.NH.R'$. From this it appears that the alkyl-derivatives of the mixed diazo-amides always split up like the unalkylated products into a mixture of the two diazo-chlorides and two alkylamines. The most feasible interpretation of these facts is that the mixed diazoamides have double the molecular weight usually assigned to them, and in support of this conclusion the authors have discovered that the mixed alkyl-diazoamides can be synthesized by simply boiling the alcoholic solutions of the other two isomerides of the triplet, thus—$X.N_2.NR'.Y + Y.N_2.NR'.X = (X.N_3R'.Y)_2$.—The atomic weight of zinc, by Dr. J. H. Gladstone and Mr. W. Hibbert. The authors have observed that when amalgamated zinc is used as anode in a zinc sulphate voltameter, the metal dissolved appears to be free from impurity. Results obtained in different voltameters with the same current showed a very close agreement, and the authors therefore determined the atomic weight of zinc by applying Faraday's law of electrolysis. For this purpose a series of copper, silver, and zinc voltameters were arranged in a simple circuit, and the quantity of zinc dissolved was compared with the weights of deposited silver and copper. The silver and copper voltameters were arranged according to the conditions shown to be best by Lord Rayleigh, Gray, and others. The zinc voltameters were almost of the same form as the silver voltameter of Lord Rayleigh. The anode was a sheet of amalgamated zinc supported so as to rest horizontally on the surface of the zinc sulphate solution, which had a specific gravity varying from 1·18 to 1·21. The mean ratio of the equivalents of silver and zinc is 3·298 ± 0·0008. Taking the atomic weight of silver as 107·93, this ratio gives 65·44 as the atomic weight of zinc. If silver is taken as 107·66, zinc = 65·29. The copper sulphate voltameter is not so accurate as the silver one, owing to the solvent action of the solution on the copper, and the ratio Zn : Cu given by the experiments (1·0322) is probably rather too high. Adopting Shaw's value for the atomic weight of copper (63·33), this ratio gives 65·37 as the atomic weight of zinc.—The amount of nitric acid in the rain-water at Rothamsted, with notes on the analysis of rain water, by Mr. R. Warrington. The rain of twenty months, analyzed by the copper-zinc method, contained an average of 0·138 of nitrogen as nitric acid per million of water; this is a little higher than that found by Way in 1855–56—namely, 0·12 per million—but is almost identical with that found by Frankland as a mean of his analyses of Rothamsted rain in 1869–70. In a whole year, 1888–89, with a rainfall of 29·27 inches, the quantity of nitric nitrogen in the rain was 0·917 lb. per acre, and the nitrogen as ammonia 2·823 lbs., or a total of 3·74 lbs.—The product of the action of sulphur on resin, by Dr. G. H. Morris.—The vapour-pressures and specific volumes of similar compounds of elements in relation to the position of those elements in the periodic system, by Prof. S. Young. Determinations have been made of the vapour-pressures and specific volumes of the four haloid derivatives of benzene and also of benzene itself, within very wide limits of temperature; benzene, fluobenzene, and chlorobenzene having been heated to their critical points, 288°·5 and 286°·55 and 360°·8 respectively. It is shown that if the four haloid derivatives are compared at such temperatures that their vapour-pressures are equal, the (absolute) temperatures and also the specific volumes bear a constant ratio to each other, whatever the common pressure. But on comparing benzene with one of its haloid derivatives it is found that these simple relations do not hold. The ratios of the absolute temperatures of benzene and fluobenzene corresponding to equal pressures are very exactly expressed by the equation $R' = R + ct$, where R' is the ratio at a pressure for which the corresponding Centigrade temperature of fluobenzene is t, $R = 0{\cdot}0838$, and $c = 0{\cdot}0000313$.—The vapour-pressures of uqinoline, by the same.

Anthropological Institute, May 28.—Mr. F. Galton, F.R.S., Vice-President, in the chair.—Lieut.-General Pitt-Rivers, F.R.S., exhibited some crania found during some recent excavations at Hunsbury Camp, and the Roman villa at Llantwit.—The Rev. H. G. Tomkins read a paper on the Hyksôs, or Shepherd-Kings, of Egypt.—In a paper on the proprietorship of trees on the ground of others, Mr. Hyde Clarke (Vice-President), showed that this was the case in Asia Minor, Melanesia, Borneo (honey-trees), India, Choto Nagpore (moura), and was supposed to be so in parts of China. He proposed the ownership of trees as a more probable origin in jurisprudence of the rights of property than ownership of land, which has no primitive value.

Paris.

Academy of Sciences, June 17.—M. Des Cloizeaux, President, in the chair.—Numerical results obtained in the study of the vitreous and metallic reflection of the visible and ultra-violet rays, by M. A. Cornu. The tables here communicated contain the values of the following elements: the wave-length, λ, of the reflected radiation; the principal incidence, $\Im$, which corresponds to a difference of phase, ϕ, equal to $\frac{1}{4}$ between the two reflected vibratory components; the coefficient H, calculated on the empirical relation between ϕ and i—

$$H = \sin(\Im - i) \cot 2\pi (\phi - \tfrac{1}{4}),$$

in the neighbourhood of the principal incidence; the coefficient k; Cauchy's coefficient of ellipticity, ϵ, calculated by the formula $H = \epsilon \sin^3 \Im$; the product $2k \cos \Im$, which should be equal to ϵ when ϵ is very small before unity. The substances studied are selenium, realgar (sulphide of arsenic), senarmontite (crystallized antimony oxide), blende, diamond, fluor-spar, and silver. In general, these numerical data confirm the conclusions already announced, especially as regards the constant increase of the positive and negative coefficient of ellipticity with the refrangibility of the reflected radiations.—On the heats of combustion and formation of the nitriles, by MM. Berthelot and Petit. The nitriles of monobasic acids (acetonitrile, propionitrile, benzonitrile, orthotolunitrile, benzyl cyanide), and those of bibasic acids (oxalic, malonic, succinic, and glutaric nitriles) have been investigated.—A short summary of the thermo-chemical method in its principles and results, as applied to anatomical studies, by M. Sappey. Attention is called to a new method of research, which has for its object the study of the intimate structure of the tissues and organs. The advantages, importance, and absolute necessity of this thermo-chemical method are insisted upon, not as superseding, but as supplementing, older processes. M. Sappey has practised it since 1860, but has hitherto refrained from publishing anything on the subject through his desire to thoroughly verify all the facts before proclaiming the new doctrine. The method itself is based on the fundamental principle of the association of calorific with chemical action in the animal organism; and in its application to the study of the tissues, cuticle, secreting glands, the stomach, ovary, &c., yields highly satisfactory, and in some instances quite startling, results, which cannot fail to challenge the attention of all physiologists.—On the prophylactic method as applied to patients after being bitten, by M. L. Pasteur. In his brief report for the year ending May 1, 1889, the Director of the Pasteur Institute announces the treatment of 1673 subjects, of whom 6 were seized with rabies during, and 4 within a fortnight after, the process. But 3 only succumbed after the treatment had been completely carried out, making one death in 554, or, including all the cases, one in 128.—On the photographic spectrum of Uranus, by Dr. W. Huggins.—Improvements in the graphophone, by Prof. C. V. Riley. Several defects inherent in Mr. Tainter's instrument are stated to have been at last completely removed by Mr. John H. White, of Washington, who has greatly improved the graphophone by employing certain appliances which have been constructed by Prof. Riley on acoustic principles.—Observations of the planet Eucharis (181), made at the west equatorial in the garden of the Paris Observatory, by M. D. Eginitis. The observations are for February 7 and 9, 1889.—On the enlargement of the spectral rays of metals, by M. Gouy. These investigations show that the so-called *narrow* metallic rays present two distinct structures. Some are widened in a uniform manner on both sides (symmetric rays), while others are enlarged almost exclusively on one side (dissymmetric rays). The difference is very marked, and the author has failed to detect any intermediate phase. Nearly all the metallic rays are symmetric, the only exceptions hitherto observed by him being those of sodium and potassium, which belong to the dissymmetric group.—On the limit between polarization and electrolysis, by M. H. Pellat. These researches lead to the establishment of a general law thus announced: Electrolysis begins the moment the double electric layer has been neutralized by polarization.—On actino-electric phenomena, by M. A. Stoletow. Owing to some improvements in the conditions of the investigation, the author has succeeded in determining more accurately the laws of the actino-electric currents in the atmosphere at ordinary pressure. He now thinks that the hypothesis attributing the actino-electric phenomena to the condensed gaseous layers which cover the metallic surfaces, must be rejected.—On the duration of lightning, by M. E. L. Trouvelot. Aided in his observations by photography, the author infers that the flash is not instantaneous, as is generally supposed, but has a perceptible duration beyond the thousandth part of a second, denied to it by Wheatstone.—Researches on the phenomenon of dispersion in organic compounds, by MM. P. Barbier and L. Roux. The first results of the researches undertaken by the authors on the dispersive power of fluid organic compounds are here communicated. The present note is confined to the monosubstituted derivatives of benzine.—M. G. A. Le Roy describes a new method of preparing nitrites of the alkaline metals; and M. Alphonse Combes contributes a paper on the action of the diamines on the diketones.

AMSTERDAM.

Royal Academy of Sciences, May 25.—Dr. H. G. van de Sande Bakhuysen in the chair.—M. Lorentz read a paper on the molecular motion of dissolved substances. The values of the osmotic pressure, which M. van't Hoff has deduced from various data, seem to indicate that this pressure is due to the molecular motion of the dissolved body, the mean kinetic energy of a molecule being equal to that of the molecule of a gas at the same temperature. These views were tested by a discussion of molecular equilibrium in a solution under the influence of external forces.—M. van de Sande Bakhuysen exhibited an instrument for determining, by means of rectangular co-ordinates, the right ascensions and declinations of stars on photographs, and the results obtained by measuring, after this method, a photograph by M. Henry. The probable error of each co-ordinate is ± 0″·043. He pointed to the great interest of photographs in the determination of the sun's parallax, and stated that during the coming opposition of Victoria, M. Henry at Paris will make photographs which are to be measured at Leyden.—M. Bierens de Haan announced that the second volume of Huyghens's correspondence will soon be published.—M. Forster treated of the influence of our common salt on the life of pathogenetic bacteria, and stated that, from many and various experiments, he had come to the conviction that, whereas cholera bacilli are very sensible to that salt, and when brought into contact with it very soon die, the typhoid and pyogenetic bacteria, the bacilli of tuberculosis, and the cattle-distemper bacilli may remain for months buried in common salt without losing their powers of growth and reproduction. The salting of butchers' meat may, therefore, in some cases prove ineffectual. M. Forster further exhibited some preparations, obtained in the hygienic laboratory, which went to prove that neither the bacilli of tuberculosis nor cholera bacilli can develop under the influence of iodoform vapour.

CONTENTS.

THURSDAY, JULY 4, 1889.

CRYPTOGAMIC BOTANY.

A Hand-book of Cryptogamic Botany. By Alfred W. Bennett, M.A., B.Sc., F.L.S., and George Murray, F.L.S. With 378 Illustrations. (London: Longmans, Green, and Co., 1889.)

THE utility of a book presenting in clear outline the present state of our knowledge of the morphology of flowerless plants cannot be doubted. The division of plants into Cryptogams and Phanerogams is, it is true, a non-natural one. As the authors of this hand-book themselves point out, the Vascular Cryptogams are "more nearly allied in many respects to the Phanerogams than to the lower Cryptogams." This fact, however, is not a serious objection to the limitation here adopted. If it is found desirable, for teaching purposes, to treat the vegetable kingdom in two divisions, the line may be as conveniently drawn between the Pteridophyta and the Gymnosperms as anywhere else. The idea of a work dealing with the families of Cryptogamic plants has been familiar to English readers since the publication of Berkeley's famous "Introduction to Cryptogamic Botany" in 1857. Since that date the literature of the subject has accumulated to an incalculable extent. A work of similar scope, written at the present day, demands enormously increased labour in compilation, and offers, perhaps, less room for originality. In the authors' view, the object of the writer of a hand-book is "to gather up and to collate material already existing, winnowing, to the best of his judgment, the wheat from the chaff." The indebtedness of the authors to their predecessors is amply acknowledged, and it may fairly be claimed for the hand-book that the arrangement of the material is to a great extent its own.

The descending order is followed throughout, the Cryptogams being divided into seven groups: Vascular Cryptogams, Muscineæ, Characeæ, Algæ, Fungi, Mycetozoa, and Protophyta. The reappearance of the Characeæ as a main group will be a surprise to those who have become accustomed (and in our opinion rightly) to regard them as green Algæ. The Mycetozoa should probably have been excluded altogether, and the Protophyta, as here limited, form a very heterogeneous collection. On the other hand, we regard the breaking up of the old sub-kingdom, Thallophyta, as a distinct gain. The character on which it was founded is of absolutely no systematic value, and the Algæ and Fungi, at any rate, are groups of sufficient extent and independence to stand by themselves.

The authors have introduced several changes in terminology. The most conspicuous, though not the most important, of these is the adoption of Anglicized terminations for Latin and Greek technical words. This is a matter in which it is hard to draw the line aright; thus we have already become used to "ovule" and "pistil" instead of "ovulum" and "pistillum." But still, as a matter of taste, we think the authors have gone much too far in this direction. They complain of the "awkward and uncouth foreign forms of these words": we should have thought this reproach applied much more strongly to "cœnobe," "sclerote," "nemathece," and "columel." It need hardly be said that the authors themselves have not succeeded in attaining consistency in this matter. Happily, we are still allowed to say "prothallus" and "nucleus," though "nucleolus" has become "nucleole," and "gleba," "glebe."

A more important point is the use of the word *spore*. The authors define a spore as "any cell produced by ordinary processes of vegetation, and not directly by a union of sexual elements, which becomes detached for the purpose of direct vegetative propagation." Thus the word is used in a narrower sense than that of de Bary in his "Fungi," or of Vines in his "Physiology of Plants." The authors' use of the word seems in itself unobjectionable, and is certainly preferable to Sachs's definition; but we do not see that anything is gained by the limitation they propose.

The substitution of "megaspore" for "macrospore" we regard as an improvement, and only hope it may be generally adopted.

For sexual products the authors make use of the termination "sperm" in the place of "spore," thus speaking of zygosperms and oosperms. For the sake of consistency they avoid using words compounded with "sperm" for male cells; thus "antherozoid" is once more substituted for "spermatozoid," while "spermatium" is replaced by "pollinoid." We cannot regard this last name as a happy one, for it suggests a false comparison with pollen-grains. As regards "spermatozoid" and "antherozoid," the reasons on both sides seem very equally balanced, though the former has the great advantage that it emphasizes the homology with the male element in the animal kingdom. The term "spermogonium" is abolished on the additional ground that the "spermogone is a true antherid," a statement which, at least in this general form, is really unwarranted by the facts. The word "reproduction" is limited to "the production of a new individual—that is, to a process of impregnation." This definition seems to us to involve far too much metaphysical hypothesis.

The section on the Vascular Cryptogams is preceded by some useful introductory remarks, in which the homologies with the Phanerogams, and the general course of development, are explained. The statement that in apogamy and apospory "either the oophyte or the sporophyte may be entirely suppressed" is, however, inaccurate; as, in the cases referred to, only the reproductive organs are (wholly or partially) suppressed, and not the generation which bears them.

The Vascular Cryptogams are divided, as in the earlier editions of Sachs's text-book, into a heterosporous and an isosporous series. This arrangement is admittedly provisional, but the difficulty in finding a truly natural arrangement does not seem to us a sufficient reason for adopting one which is manifestly artificial.

The Rhizocarps are the class first described. The only criticism of importance which suggests itself here is that the clear relation of these plants to the isosporous Ferns is insufficiently brought out. The other heterosporous class is the widely different group Selaginellaceæ, including Selaginella and Isoëtes. The following sentence (occurring in the account of the latter genus) is very misleading: "The mode of development of the megaspores presents perhaps the closest analogy to that of the secondary embryo-sacs of Gymnosperms that occurs in any order of Vascular Cryptogams; and the same remark applies to the formation of the microsporanges and pollen-sacs." The structures compared in the latter part of this sentence are homologous; the "secondary embryo-sacs" and megaspores are certainly not so, nor do we see in what sense there is even any "analogy" between them.

The isosporous series is divided into Lycopodiaceæ, Filices, Ophioglossaceæ, and Equisetaceæ. We are glad to see that some account of Treub's classical observations on the sexual generation of Lycopodium is given. In Psilotum the sporangia are described as "plurilocular," and are then said to be "collected into groups of three or four." These two views of the morphology cannot both be true.

The class Filices, as here limited, includes the Marattiaceæ but not the Ophioglossaceæ, an arrangement which we do not think an improvement. At p. 71, the *stem* of Lygodium is wrongly said to be scandent, in contradiction to the correct account given a few pages later on. Slips of this kind are rather frequent in the book, and should be looked to in a future edition.

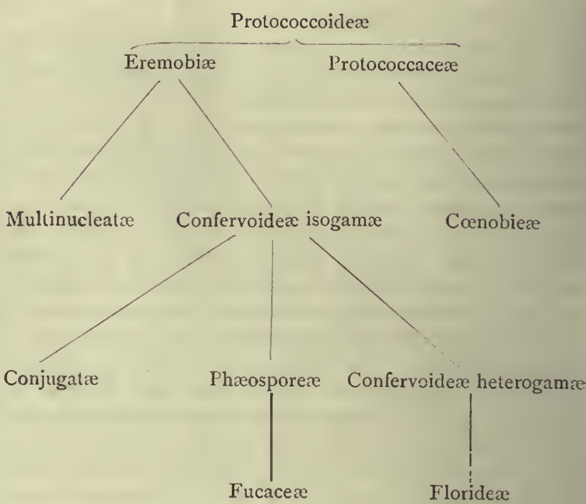
The sections on the Ophioglossaceæ and Equisetaceæ call for no special remark, except that we find Sachs's original description of the division of the spore mother-cells in Equisetum reproduced. The process is a perfectly typical case of cell-division (not "free cell-formation"), and called for no special description here; while Sachs's account, however interesting historically, is now fifteen years out of date.

An interesting notice of fossil Vascular Cryptogams concludes this subdivision. Attention may especially be called to the excellent figure of the stem of Psaronius, which, by the way, is referred to Cyatheaceæ—not, as by Solms-Laubach, to Marattiaceæ. This chapter will be very welcome to English students.

The second subdivision, Muscineæ, is divided as usual into Musci and Hepaticæ. The treatment of these classes, though not very full, is otherwise satisfactory. By an unfortunate mistake, the protonema of the Mosses is twice over described as colourless (pp. 134 and 140). We think that it is undesirable to speak of the archegonia as in any sense "corresponding to the pistil in flowering plants" (p. 141). Expressions of this kind are very likely to mislead the beginner, and the same objection applies to the term "stigmatic cells" for the cells at the apex of the archegonium.

As mentioned above, the Characeæ are separated from the Algæ as a distinct subdivision. The reasons given for this separation do not appear sufficient. Much higher morphological differentiation of the vegetative organs is found among undoubted Algæ, while the great number of Algal characters presented by the Characeæ seem to us to outweigh the points of peculiarity in their reproductive organs. However, the true position of this group is likely long to remain a *vexata quæstio*.

The Algæ themselves are treated at considerable length (120 pages), and the account given is the fullest in any general English work. The authors may be congratulated on being the first in this country to attempt an adequate summary of our knowledge of these plants: as might be expected, however, there are many points which invite criticism. The Algæ are ranged in eight classes: Florideæ, Confervoideæ heterogamæ, Fucaceæ, Phæosporeæ, Conjugatæ, Confervoideæ isogamæ, Multinucleatæ, and Cœnobieæ. The authors' opinion as to the phylogeny of these classes may perhaps be best represented in a tabular form. All Algæ are derived by them from the Protococcoideæ, the latter group being placed among the Protophyta.



On the whole, this arrangement seems to us as good as any which has been proposed, though it is necessarily provisional. We cannot agree that the Dictyotaceæ connect the Fucaceæ with the Phæosporeæ through the Cutleriaceæ. The resemblance between the latter and Dictyotaceæ is a very superficial one. Nor are we satisfied that Coleochæte really marks the transition from oosporous Confervoideæ to Florideæ. Falkenberg has already shown how slender the grounds are for this supposition. We should be disposed to seek the origin of the red seaweeds much lower down in the scale, but in the present state of knowledge it is quite impossible to decide this point.

The Porphyraceæ and Ulvaceæ are included among the Florideæ as degraded forms. The Ulvaceæ, however, have no Floridean characters whatever, and show clear relationships to such Palmelloid forms as Tetraspora, a fact which the authors themselves recognize (p. 418). If, as is possible, Porphyraceæ and Ulvaceæ are really related, the former group will have to be separated again from the Florideæ, with which it has been somewhat too hastily associated on the ground of Berthold's observations.

It is impossible to consider all the authors' classes in detail. As regards the brown Algæ, we do not think it is correct to say that the differentiation of *tissues* in the Laminariaceæ is less strongly developed than in the Fucaceæ, and we entirely decline to believe that the unilocular sporangia of Cladostephus are due to the attacks of parasitic Chytridiaceæ! (p. 250). The Conjugatæ are fully described, but there is some confusion in the use of the words "zygosperm" and "hypnospore" in the order Mesocarpeæ. The class Multinucleatæ corresponds to Siphoneæ in the widest sense. We cannot agree with the authors in regarding Vaucheria as the "culminating genus" of this class. It is inferior to most Siphoneæ in every respect except the heterogamous reproduction.

In the class Cœnobieæ the orders Pandorineæ and Volvocineæ should, we think, have been united, or at least placed in juxtaposition.

A few words on fossil Algæ conclude this section.

The fifth subdivision, Fungi, is very clearly described, in general agreement with de Bary's views. The Fungi are divided into Phycomycetes and Sporocarpeæ, the former including the Oomycetes and Zygomycetes, the latter the Ascomycetes, Uredineæ, and Basidiomycetes. We may note that the Ustilagineæ are included among the Zygomycetes, de Bary's opinion as to the sexuality of the cell-fusions in the former groups being adopted, while Brefeld's opposite view is severely criticized. The phenomena in question are really on the confines of sexuality, and both opinions are tenable. It may be, however, that we have a definite test in the fusion of nuclei, and if Fisch's observations are to be trusted this test goes against the sexuality of the Ustilagineæ.

The account of the Ascomycetes is essentially based on de Bary's work. Due stress is laid on all the cases in which it is possible to find any indication of sexual reproduction. Perhaps it would have been better to point out that there are two sides to the question, and that the views of Brefeld, van Tieghem, and Moeller also have to be taken into account.

The statement that a nucleus has not yet been demonstrated in yeast-cells shows an excess of scepticism. The evidence afforded by Zacharias's observations is as convincing as in the case of any other fungal cells.

The Uredineæ are rather curtly disposed of. In tracing their relationship to the Basidiomycetes, the authors regard the teleutospores and basidiospores as corresponding structures. Several facts may be adduced in support of this view, but on the whole we prefer de Bary's ingenious interpretation, according to which the teleutospores are homologous with the basidia, the promycelium with the sterigmata, and the sporidia with the basidiospores. This comparison rests on very strong evidence, as an inspection of Figs. 130 and 140 in de Bary's "Fungi" will show.

The next subdivision is that of the Mycetozoa. If, as the authors, in agreement with most authorities, state, "we are justified in placing the Mycetozoa outside the limits of the vegetable kingdom" (p. 406), it seems to be time that these organisms were excluded from botanical hand-books.

The last subdivision, Protophyta, is a most heterogeneous group, including the Protococcoideæ, Diatomaceæ, Cyanophyceæ, and Bacteria. In our opinion, the two first-named groups would have been much better placed among the Algæ, and the same probably applies to the Cyanophyceæ, though here there is more room for doubt. This would only leave the Bacteria, and these must eventually accompany the Cyanophyceæ, from which they seem to differ in nothing except the usual absence of chlorophyll. It must be mentioned, however, that the authors themselves fully recognize that the Protophyta are not a natural subdivision.

The work as a whole is a useful summary of Cryptogamic morphology, but there is room for very material emendation. Many inaccuracies occur, some of which have been noticed above, and though these mistakes are no doubt largely due to oversights in revision, they are none the less misleading to the reader. We think also that in some cases, especially as regards the Vascular Cryptogams and the Protophyta, the authors have not made sufficient effort to render their classification as natural a one as possible.

It is especially to be regretted that so few good new figures have been introduced. Nothing adds so much to the freshness and interest of a hand-book as good and original illustrations, while the constant reappearance of familiar text-book figures, however well selected, has become very wearisome, and is unworthy of a living and active science.

We hope that opportunity may be found in a second edition to render this book in every way a satisfactory account of flowerless plants. It should be mentioned that there is a very good and complete index.

D. H. S.

AN ENGLISH RAILWAY.

The Working and Management of an English Railway. By George Findlay, General Manager of the London and North-Western Railway. (London: Whittaker and Co., 1889.)

To write a good book on the working and management of an English railway is no easy matter. The author of such a work must have an intimate knowledge of his subject, and be in a position to take one of our best English railways for his pattern. It would be quite possible to name more than one railway in this country, the management of which would, if described in a book, serve to illustrate how such a task should not be fulfilled. This, however, does not apply to the present volume. It is a pleasure to read a book on the subject by Mr. Findlay, the General Manager of the London and North-Western Railway, for where would it be possible to find a better managed line than the North-Western Railway?

In a volume of 270 pages, divided into sixteen chapters, the author treats departmentally the various sections of staff and plant necessary for the efficient working and control of this vast system of railways. Chapter ii. deals with the management of the line, and it is evident that this is most thoroughly carried out by means of a system of devolution of responsibility. The author says, "It will thus be seen that the chain of responsibility and supervision is a very complete one, and, in fact, the secret of organizing the management of a great service, such as this, is nothing more than a carefully arranged system of devolution combined with watchful supervision." The staff consists of about 55,000 men, including all grades in the service. It is interesting to note that promotion does not depend on seniority, but solely on merit, the best man for the particular post being chosen; and this no doubt is the only way of getting work well done.

In the chapter on the "Permanent Way" the subject is treated historically. The old cast-iron rails laid on stone blocks are illustrated as a relic of the early days of railways, and the reader is gradually led through the various changes and improvements made therein, until he reaches the standard road of the North-Western of to-day, which is as nearly perfect as it can be made with our present knowledge. Signals and interlocking are efficiently dealt with in chapter v. Then the telegraphs are equally well described in chapter vi. The rolling-stock of a railway forms probably the most important part of the necessary plant, and is affected more than anything else by the gradually increasing speeds and weights of trains. Chapters vii. and viii. deal with this important subject. The standard types of locomotives are very well illustrated, but the descriptions might with advantage have been more detailed. The author discusses the necessity for an increase of power in the passenger locomotives to cope with the increased weight of the principal express trains, and the solution of the problem by the introduction of Mr. Webb's fine compound locomotives. The construction and working of these engines are described clearly enough for the benefit of non-professional readers. It would have been interesting to find an account of the Worsdell compound locomotive, which, although not in use on the North-Western, has many points in its favour. Comparing it with Mr. Webb's engine, many engineers consider it the better engine of the two. Perhaps in a future edition Mr. Findlay might add a description of it, with an illustration.

Carriages and different kinds of rolling-stock are well dealt with, and it is evident that the author has taken the utmost pains to get his information up to date. The locomotive works at Crewe, and the carriage and waggon works at Wolverton, are capitally described. With reference to the automatic vacuum brake, described on p. 120, it is evident that this brake is automatic on the coaches *as well as* on the guards' vans. As this is probably of recent introduction, the North-Western Company are to be congratulated on its adoption in their rolling-stock. The earlier vacuum brake fitted was nothing more than the simple non-automatic vacuum brake as far as the coaches were concerned, and was justly condemned by most railway engineers for that reason.

The remaining chapters deal with the working of the trains, shunting and marshalling of goods trains, the working of goods stations, rates, fares, traffic, &c. With regard to all these matters the writer's statements are clear, concise, and to the point.

It would be of great service to the railway world generally if some of the head officials of the best English railways would follow Mr. Findlay's example, and give us some of their stores of experience. Take, for instance, locomotive engineering: where is the student or apprentice to find a book of recent date on the design, construction, and working of the modern locomotive? Let us hope that the infection will spread on the North-Western staff, and that by and by Mr. F. W. Webb, the able Locomotive Superintendent of that railway, will write a book on the department in which he so greatly excels.

Mr. Findlay's book displays so much knowlege and ability that it well deserves to rank as a standard work on the subject. N. J. L.

OUR BOOK SHELF.

Zur Geologie der Schweizeralpen. Von Dr. Carl Schmidt. One Plate. (Basel: Benno Schwabe, 1889.)

THIS pamphlet gives a summary of the views entertained at the present time by many leading Swiss geologists as to the geological history of the Alps. So far as we can see, it does not profess to be more than a compilation, or to contain any original work; but as a summary it is as clear and concise as the subject permits. The author, in the first chapter, briefly sketches the history of the principal types of rock which enter into the composition of the Alps; and, as might be expected at the present juncture, lays much stress upon the results of pressure. Some, indeed, may think that the present moment is rather inopportune for such a memoir as this; for the modifications due to pressure, especially in rocks already crystalline, are still the subject of so much controversy among geologists, that it is difficult to know what may be taken for granted; and there is a danger, if the writer be a disciple of the new school, of confusing the results of demonstration and of hypothesis. A quotation (translated) will indicate the author's point of view better than a general statement. After pointing out that two great rock groups exist in the Alps, one consisting of various granitoid rocks, gneisses, and crystalline schists, the other of limestones, sandstones, and other sediments, he proceeds—"In Switzerland the region which intervenes between the two zones is not very broad. The general strike of this intermediate zone is through Coire, Ilanz, the Greina Pass, Scopi, Airolo, Nufenen, the Rhone Valley, to Martigny, and so through the Val Ferret to the Little St. Bernard. The rocks of this intermediate zone are crystalline sediments, the age of which it is difficult to fix with precision. In the Grisons they have lately been claimed by Gümbel as Palæozoic, in the Valais they have been shown by Lory to be Triassic: that the same, from the Greina Pass to the Nufenen, are Jurassic, can be proved by fossils." This, however, begs the whole question. It has yet to be shown that the Swiss geologists have not confused together, as some maintain, two distinct rock groups, owing to their having mistaken (not for the first time) for crystalline schists, deposits which only simulate the latter, because they are locally composed almost entirely of their *débris*.

But, putting aside theoretical and controversial matters, the author's summary is generally clear. It would, we think, have been more useful if he had condensed somewhat the general discussion in the opening chapter, and dwelt more fully in the others on the many interesting questions of local physiography which are opened up by a study of the Alps. To this objection, however, an exception must be made in the case of the nagelflue, where Dr. Schmidt's remarks are very interesting. In certain of these great masses of conglomerate, pebbles of crystalline rocks are fairly common. These, he states, whether granites, gneisses, or crystalline schists, show no indications of the dynamic metamorphism which is exhibited by similar rocks in the adjoining chain of the Alps. From this observation, if confirmed by further research, it would result that the "schistosity," or secondary foliation, which is so marked a feature in most parts of the Alps, has resulted not from the post-Eocene but from the post-Miocene set of movements.

Die Entstehung der Arten durch räumliche Sonderung. Gesammelte Aufsätze von Moriz Wagner. Herausgegeben von Dr. med. Moriz Wagner. (Basel: Schwabe, 1889.)

OF later years, zoological literature has been significantly full of contributions, advocating now addition to, now subtraction from, the theory of "evolution by means of natural selection" formulated by Darwin—contributions, the chief characteristics of which are that they are mutually destructive, that they are, comparatively speaking, unsupported by any serious array of observed facts, and that none of them meet with more than a few adherents. We do not believe that truth is appreciably advanced by ingenious speculation of that nature; it is certainly in so far retarded that the energy thus expended would have been better applied in placing Darwin's conclusions under severe and prolonged tests, such as those attempted in Fritz Müller's "Für Darwin," and in Weismann's study of the markings of Lepidopteran larvæ. As Semper pointed out long ago (and too much insistence cannot be laid upon it), the present need is not for fine-spun theory—we have theories galore—but for the judicious compilation of facts selected where the leverage will tell, facts which shall either upset or confirm—it matters not which—the theory of natural selection.

The book before us must be classed among the speculative works just mentioned; and the gist of the author's views may be gathered from the following paragraph, written in 1880 (p. 401):—"Every permanent new form (species or variety) commences with the isolation of individual emigrants, separated for a prolonged period from the habitat of some parent species which is in the stage of variability. The active factors in the process are: (1) adaptation of the immigrant colonists to the external conditions of the new habitat (nutrition, climate, soil-composition, competition); and (2) the impression and development of the individual characteristics of the first colonists upon and in their posterity by reason of the breeding between near kin. This formative process ceases as soon as, owing to rapid multiplication, the levelling and compensating effects of intercrossing make themselves felt, resulting in and maintaining that uniformity which characterizes every good species and permanent variety." Wagner's hypothesis exalts the importance of geographical isolation at the expense of natural selection, and thus approximates, both at starting-point and conclusion, to Mr. Gulick's recent theory of "divergent evolution through cumulative segregation" (Journ. Linnean Soc., vol. xx. p. 189), though in detail the respective courses taken by the two writers are by no means identical.

Consisting of a reprint of articles published between 1868–86, mainly in *Kosmos*, *Das Ausland*, and the *Allgemeine Zeitung*, the matter of the book has been long before the public, and its conclusions have been attacked from time to time by Haeckel, Weismann, Oscar Schmidt, and others; a translation of the first, and perhaps the most important article, has appeared in London (Stanford, 1873): criticism of the theory in this place is therefore unnecessary. The present reprint is edited by Wagner's nephew and namesake, in accordance with a wish expressed some time before his death in 1887, and contains, besides the articles previously published, a biographical sketch by Dr. von Scherzer, and editorial introductions; while the last 127 pages are devoted to an attempt of the editor to build certain recent discoveries, such as those of the *Challenger*, into the original structure. It is hardly necessary to say that, being a close-printed German octavo of 667 pages, the book possesses no index.

Sylvan Folk. By John Watson. (London: T. Fisher Unwin, 1889.)

MR. WATSON expresses much contempt for what he calls "the dry bones of science." We are not sure that we quite understand what he means by this expression, but it evidently does not imply that he dislikes results obtained by careful and exact observation. In the present little volume he gives ample proof that he often brings himself face to face with Nature, and that he knows how to interpret many of the innumerable signs and symbols which are readily misunderstood, or altogether overlooked, by less careful inquirers. Mr. Watson is especially happy in his notes upon the ways of birds; but he has also interesting chapters on mice, voles, and shrews, on red deer, fallow, and roe, on British seals, on British fur-bearers, and on "Nature by night." There is not much that is absolutely new in any of the information he has brought together; but his descriptions are so fresh—they suggest so vividly the idea of happy hours spent among attractive scenes in the open air—that they will give genuine pleasure to everyone who reads them. The book will be especially interesting to young readers, who will be glad to learn that it depends very much upon themselves, according to Mr. Watson, whether they shall be on terms of intimacy with the wildest woodland creatures. Mr. Watson thinks that the power of attracting wild creatures was once a much more common possession than it is now.

A Practical Guide to the Climates and Weather of India, Ceylon, and Burmah, &c. By Henry F. Blanford, F.R.S. Pp. 369. (London: Macmillan and Co., 1889.)

THE appearance of this book is very opportune. The Indian Meteorological Office has been in existence for some twenty years, and inasmuch as the region over which its operations extend comprises a very considerable area of the earth's surface, representing climatological conditions of the most varied character, a general *résumé* of the information as to these conditions is one of the most important contributions to climatology that could be made.

Mr. Blanford has well fulfilled his task. He says his work "is not addressed to meteorologists and physicists, ... but more particularly to agriculturalists, medical officers, engineers, pilots and other seafaring men, and to those others of the general public to whom the weather and the climates of India and of its seas are practical and not scientific objects of interest."

The book is divided into two parts: (1) the elements of climate and weather; (2) the climates and weather in relation to health and industry.

The former is naturally the more technical, while the latter appeals to the general public, as it gives a detailed description of the climates of the principal and most frequented hill stations, as well as of the plains, under which latter general head the different provinces or districts receive each a separate notice.

One section is specially devoted to the storms of the Indian Seas. In their discussion Mr. Blanford is a pronounced adherent of the spiral in-draft theory in contradistinction to the old circular theory and the well-known "eight-point rule."

About the most valuable chapter is the last, which is mainly occupied with rainfall and evaporation. The questions relating to these are of paramount importance for the bare existence of millions of the population. Such a famine as that of 1834 in the Doab was sufficient to induce the authorities of the day to construct the Ganges Canal, the greatest work of the kind in the world, and one which has in a great measure corrected the injurious effects of irregularity in the rainfall.

The appendixes give the tabular results of the instrumental records, which are required to substantiate the general statements contained in the previous pages.

The work is a most creditable production, and it will long remain the standard authority on any question bearing on the climate of the Indian Peninsula.

The Unrivalled Atlas. Enlarged Edition (18th). (London and Edinburgh: W. and A. K. Johnston, 1889.)

A NEW and enlarged edition of this atlas has just been published. The forty maps which it contains are well engraved and especially full of information concerning railway communication, whilst the fact that the index contains 20,000 names of places, with their latitude and longitude, testifies to its completeness. An extension of the atlas has been made by the addition of two classical maps, with an index to them, two physical maps of the British Isles and Europe, and two astronomical plates, each being accompanied with descriptive letterpress. A misleading paragraph occurs in the explanation of tidal action. We read: "The moon exerts a much greater influence on the production of tides than the sun; for, though its mass is excessively small in proportion, it is four hundred times nearer the earth." The inference that a beginner would draw from such a paragraph would be that the predominant effect of the moon in causing tides was simply due to its proximity to the earth, whereas the fact cannot be too strongly insisted upon, that it is the differential attraction of the sun and moon upon the earth's surface and centre that causes tidal action. The atlas is complete and trustworthy.

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.*]

Coral Reefs.

I BELIEVE all the questions asked by Captain W. Usborne Moore in NATURE of June 27 (p. 203) have been already answered in my papers on this subject. However, as I have examined the reefs at Kandavu, Matuku, Ovalau, and other places at the Fiji Islands, I may attempt to answer his questions with reference to these special cases.

According to Mr. Darwin's view, an island equal in extent to the lagoon of an atoll has sunk from view and the circular reef that has grown up marks approximately the position of the ancient coast line. In the case of a barrier reef, land equal in area to the lagoon channels has been submerged, the barrier reef here, too, marking the position of the ancient coast line. The opponents of Mr. Darwin's theory hold that there is no sufficient evidence that any such land once occupied the site of the lagoons and lagoon channels. I believe they might go further, and hold that, had such extensive submergence taken place, these lagoons and reefs would necessarily present features other than those by which they are everywhere characterized in our seas at the present time.

We hold that all the phenomena presented by these coral reefs and islands can be better explained on other principles without calling in subsidence; that slow subsidence or elevation or rest would only modify in a minor way the general features of a reef; that any one of the three kinds of reefs may be formed indifferently in a rising, sinking, or stationary area. In a sinking area the lagoons would probably be relatively deeper, the reefs narrower, and the islands on them small or absent; in a rising area the lagoons would be relatively shallower, the reefs broader, and the islands more numerous or united into a continuous band of land.

In surveying the coasts of any volcanic islands situated in the ocean where there are no coral reefs, Captain Moore must know that these are sometimes surrounded by banks extending much further seawards in one direction than in another. These banks are doubtless formed of the loose materials of the island, which are spread out by wave action. The position of these banks depends on the nature of the rocks in the different parts of the islands; in the case of Graham Island, the whole island was spread out, forming a submerged bank. In addition to the nature of the materials, the depth over the banks depends also on the extent and depth of the surrounding seas. The 20, 50, or 100 fathom line follows sometimes the shape of the coast within, sometimes differs widely from the shape of the coast, just the same as barrier reefs do.

The Fijis are, in my opinion, such a volcanic group, where the shallower waters have now become the home of myriads of lime-secreting organisms. These have built up the wholly submerged banks into atolls, and the banks around islands into barrier reefs, the depth and distance from land most favourable for vigorous coral growth being determined by a variety of local circumstances. When the reef reaches the surface, it spreads seawards. There is, of course, plenty of living coral in the lagoons, but this becomes less and less as the reef becomes more continuous and less oceanic water is admitted. The growth of corals is always, however, much less vigorous and much less rapid in lagoons than on the seaward faces of reefs. The position of the opening in the reef is determined by local conditions, such as the mud from rivers in the case of barrier reefs. I have elsewhere fully explained my view as to the removal of dead coral, and even coral heads and islands, from the lagoons, through solution of the lime by sea-water.

I cannot have seen as much of Kandavu as Captain Moore, but what I did see in no way led me to believe that it was a sinking island;[1] indeed it was here that, not being able to apply Mr. Darwin's theory in explanation of the phenomena of the Kandavu reefs, I commenced to doubt it altogether. The coast around Cape Washington (the western end) appears to be particularly unfavourable for the formation of extensive reefs, because of the high land (2750 feet) and deep water, hence we have only narrow fringing reefs or no reefs. At the north end the extensive banks surrounding the islets are, on the other hand, specially favourable for coral growth, owing to the almost complete absence of rivers and of detritus from the land; here we have what might be called an atoll, except for the presence of the small rocks, which, after reaching the surface, has extended seawards.

If Captain Moore thinks the rock, Solo, was once an island about four miles in diameter and of considerable height, he must explain how in sinking it has left a lagoon around the remaining rock with an average depth of not more that 12 fathoms. He must also explain the nature of the bank extending west from Ono, where there is no continuous barrier.

It is in every way desirable that practical surveyors like Captain Moore should take an interest in these theoretical views, and their observations will be none the less welcome and appreciated whatever side they may take in the controversy. The more observations accumulate the more does it seem to me probable that there never was a barrier reef or atoll formed after the manner required by Mr. Darwin's theory. If Profs. Dana, Bonney, Huxley, and Judd, would mention any one barrier reef and any one atoll that they believe undoubtedly to have been formed in accordance with the subsidence theory, then I think it might be possible within the next few years to undertake a thorough examination of these with the view of testing the rival theories.

Challenger Office, Edinburgh. JOHN MURRAY.

I HAVE been immersed in examinations, and away from London for a few days, so that I did not see Mr. Guppy's letter in NATURE of June 20 (p. 173) till it was too late to reply. I will now only ask space for a few last words. To me the matter does not appear to have "resolved itself into an affair of outposts." The position which I was led to take up from the study of the recent literature on coral reefs, and which I had hoped that I had made clear in my last letter, is this—that till Mr. Guppy can produce cases of *growing reefs* at depths well exceeding 25 fathoms, isolated instances of the occurrence, at such depths, of living corals which are among the reef-builders do not really help him; and that till he can do this he is only supporting hypothesis by hypothesis. For example, I have not seldom, in the Alps, gathered phanerogamous plants, flourishing and in full bloom, at elevations of eleven or even twelve thousand feet above the sea; but I should not direct anyone to this mountain zone who desired to pick a posy of Alpine flowers.

Into the remainder of Mr. Guppy's letter it would be waste of time to enter, or to continue this controversy, for two reasons: one, that evidently Mr. Guppy and myself differ widely as to the nature of hypothesis, and the difference between assumption and proof; the other, that I trust, before another number of NATURE appears, to be among the Alps (with strict orders against forwarding letters or papers), so that any return shots will fail to reach me, until, in this rapidly-moving world, they have passed into the region of ancient history.

June 28. T. G. BONNEY.

BEFORE replying to Captain Moore, I should bear witness to the searching character of his questions, which quite makes up for the fact that during his valuable services of many years abroad he has been, fortunately perhaps, beyond the reach of recent coral reef literature.

However, I would first point out that when he speaks of the second edition of Mr. Darwin's "Coral Reefs," which was published fifteen years ago (1874), as given to the world "after forty years of deep research into various problems of Nature," he surely forgets that after the first edition of 1842 the author had no further acquaintance with coral reefs. Captain Moore also omits to reflect that during the interval between the two editions Dana and Jukes were the only two principal observers that stood up

[1] See "Narrative of the *Challenger* Expedition," vol. i. p. 507.

for Darwin, whilst against them were ranged L. Agassiz, Le Conte, Hunt, Semper, and Rein. One might with equal justice claim for an eminent engineer that a bridge constructed by him as a young man in 1842 and repaired by him when an elderly man in 1874, represented the accumulated experience of a long professional career, notwithstanding that he had never since erected another bridge, and had devoted all his time to works of a very different character, and in spite of the fact that, whilst only two engineers of reputation had in the interval pronounced the bridge to be safe, five others of equal eminence had advised that, owing to its rickety condition, it should be pulled down. If it was a question of personal safety, most people would trust to the opinion of the many.

I will first clear the way by laying stress on the circumstance that neither A. Agassiz nor Murray doubt the reality of subsidence. They only contend that the characteristic form of atolls and barrier reefs is not dependent on it, and that such reefs would be produced by their natural mode of growth alone.

Now, with regard to Fiji, Captain Moore is perhaps not aware that in the writings of Murray, Semper, Geikie, and others, in these columns and elsewhere, the association of the three classes of reefs in the same group, as in Fiji, has often been referred to as opposed to the theory of subsidence. It was the occurrence of all reefs in the Fijis and in the Pelew Group, and the ascertained existence of upraised reefs in the last locality, that amongst other reasons led Murray and Semper to find some different explanation than that of subsidence. Dana saw the difficulty, and tried to avoid it by asserting that small fringing reefs are "often evidence of subsidence, even a greater subsidence than is implied by barrier reefs" (*Amer. Journ. Science and Arts*, 3rd series, vol. viii., p. 316). Semper, however, pointed out that this conclusion at once destroyed the value of the testimony afforded by coral reefs of the movements of the earth's crust, since, if all kinds of reefs can be formed during subsidence, the character of a reef cannot guide us in determining the existence of subsidence or upheaval ("Animal Life," p. 233). Darwin also saw the difficulty of the Pelew Group, where living atolls, barrier reefs, and fringing reefs were associated with upraised ancient reefs; and thus it came about that, when writing to Semper in 1879, he generously observed that, although he still adhered to the theory of subsidence, such cases as that of the Pelew Islands, if of at all frequent occurrence, would make his conclusions of very little value. "Future observers," he went on to say, "must decide between us," &c. (Semper's "Animal Life," p. 456).

I contend that in 1889 Mr. Darwin's condition has already been realized, since we have in the interval proved that in respect to the occurrence in the same locality of all three classes of coral reefs and their association with ancient upraised reefs, the Fijis, the Tongan Group, and the Solomon Islands are but reproductions of the Pelew Group. It will therefore be seen that Captain Moore is in error when he believes that Darwin would not have regarded simultaneous up and down movements in the same group as inconsistent with his theory. Darwin's admission to Prof. Semper in the case of the Pelews shows plainly enough what he would have thought of the Fijis. This difficulty of imagining simultaneous up and down movements in the same group was also perceived by the present Director-General of the Geological Survey, when he remarked some years ago in these columns that "such an association of upheaval with an assumed general subsidence requires, on the subsidence theory, a cumbrous and entirely hypothetical series of upward and downward movements" (NATURE, vol. xxix. p. 107; Proc. Roy. Phys. Soc., viii.).

It is somewhat remarkable that long as the Fiji Group has been known, it is only of recent years that anything has been published concerning its upraised coral reefs and its other evidences of considerable upheaval. Darwin, as late as his edition of 1874, knew nothing of the extensively upraised reefs, and he still coloured the group in his map as in an area of subsidence. Strangely enough, amongst the many errors perpetuated in the edition published in the present year of Mr. Darwin's work, is that relating to this group. In an additional footnote (p. 215) we find no reference to the ancient coral reefs upraised some hundreds of feet in the Lau or Windward Group, which are referred to in the Hydrographic publication of 1882 concerning Fiji, and which were described to me by Lieut. Malan some years ago. We find no reference in this edition of 1889 to the conclusion of Mr. Brady that the Suva soapstone, as indicated by its Foraminifera, was formed in depths of from 150 to 200 fathoms in post-Tertiary times, thus implying an upheaval of from 900 to 1200 feet (Geol. Soc., November 9, 1887). Curious as it may appear, Dana, after his lengthened stay in the group, found proofs of an elevation in the larger islands of only 5 or 6 feet, and was inclined to negative it altogether in the case of the eastern islands ("Corals and Coral Islands," 1872, pp. 342, 346).

Captain Moore refers to the "many evidences of upheaval" in Fiji, and instances the occurrence of shells and coral "at great heights." What evidence has he of subsidence? He points to the form of the reef in various islands, and thus assumes the very question at issue. However, I will leave to Mr. Murray to explain how these reefs attained their characteristic form without the assumed movement of subsidence, of which in fact we can find no direct proof.

H. B. GUPPY.

As Dr. Guppy asks for information with regard to the corals found living at the greater depths round islands in the Indian and Pacific Oceans the following may be of interest.

About two years ago Capt. Wharton, F.R.S., called attention to the Tizard Bank, and last year both it and the Macclesfield Banks were examined by H.M.S. *Rambler*.

The further investigation of the material sent home has shown that the large number of eighteen genera with forty species were found living in depths from 20–44 fathoms outside the reefs, and these species differed with but few exceptions from those in the shallow water.

The following ten genera were found at a greater depth than 30 fathoms—Stylophora, Astræa, Pavonia, Cycloseris, Leptoseris, Stephanaria, Psammocora, Montipora, Alveopora, and Rhodarœa, besides seven small scarcely reef-building genera.

The total number of species collected was 142, so that nearly one-third were represented in over 20 fathoms.

P. W. BASSETT-SMITH, R.N.

Hibernation of Martins in the Argentine Republic.

PROF. CARLO SPEGAZZINI, an Italian botanist, and quite a trustworthy observer, living at La Plata, the new town in the Argentine Republic, writes from there the following account to my friend the Marquis Giacomo Doria of Genoa:—

"The bird known here by the name of *Golondrina*, and which I think is *Progne domestica*,[1] is subject to hibernation. Last year, while the zinc roof of a small house was being taken up in the month of August, just in the middle of our winter, I found underneath about a hundred martins, all accumulated one over the other and lethargic, but in good health, so that, exposed to the sun, they awoke and flew away very briskly. This year, again, having seen some holes on a *barrancha*, a steep bank over the Plata, I began to dig at them, hoping to find some bats; but there I found several hundreds of the martins of the same kind as above mentioned, clustered and in a state of lethargy. Is such a thing known to naturalists?"

TOMMASO SALVADORI.

Zoological Museum, Turin, June 18.

Atmospheric Electricity.

THE interesting accounts of certain electrical phenomena of the atmosphere in NATURE of May 16, 23, and 30, lead me to state that it is a common experience of surveying parties, especially on the high peaks and slopes in the western part of this country to undergo these peculiar electrical sensations. In general these may be described as tingling or pricking sensations, accompanied with hissing or crackling sounds, especially marked if a finger be presented to any metallic object near by. But further than this it has been noticed that whenever a flash of lightning occurs there is a sudden cessation of the distressing electrical effects. The explanation of this is, we think, found in some experiments made at the top of the Washington Monument (elevation 500 feet) during thunderstorms. With a "water dropper collecter," Mascart insulators and quadrant electrometer, we measured the difference of the electrical potential of the air and the ground. The electrometer needle becomes very active with the approach of the "thunder-heads," and after considerable oscillation begins to move steadily in one direction as if subjected to a steadily increasing "pull," and then suddenly, when a potential difference of several thousand volts may be indicated, there is an "instant" drop to zero, and apparent rebound in the other direction, not due to the torsion of the

[1] Or more likely *Progne chalybœa*, Gm.—T. S.

suspending wire-fibre. The drop to zero is simultaneous with each flash of lightning. So certain is this relation that we can time the lightning flashes without seeing them. After the flash the needle begins to again move in one direction, repeating its previous behaviour, so that our electrometer measurements seem to prove that every flash of lightning relieves the state of stress of the air, which we may compare with the glass in a Leyden jar, the cloud and ground being the respective coatings.

We may also get at the same result by noticing the effects of the electrification of the dust, smoke, water, and other matter in the air. Whenever our "collector" was "grounded," the fine stream of water issuing from it preserved a certain even rounded form, breaking into drops some four inches away from the place of exit. Removing the "ground" connection, and the stream being now under the influence of the thunder-clouds, the steadily increasing electrification shows itself in the stream's twisting and splitting into innumerable threads and spray; but with each flash of lightning the distortion instantly ceases, and the stream has its normal character, only to be again distorted.

For the benefit of those wishing to photograph lightning I suggest this as a cheap and easy mode of getting warning when to expose. A small tin case with a nozzle giving a fine thread of water or any form of the "burning match" device, well insulated from the ground, and at some elevation, will indicate by changes in the character of the stream or smoke, the approximate degree of the electrification of the air.

New York, U.S.A., June 20. ALEXANDER McADIE.

Upper Wind Currents over the Equator in the Atlantic Ocean.

REFERRING to the remarks of the Hon. Ralph Abercromby on the above in NATURE of May 30 (p. 101), I would ask for the longitude and latitude for the two crossings of the doldrums, to enable one properly to follow, and eventually work out, the facts. For if our famous meteorologist, on the outer journey, passed within one hundred miles of the West Coast of Africa, the great chain of desert lands, extending many hundreds of miles through Asia to the Sahara in the main weather thoroughfare, would, by its influence, very much contract the width of the calm belt, and otherwise draw the doldrum much north of the line to what would be found more to the westward, where, as it neared the American coast, the breadth of the doldrum belt would very greatly increase; so that, unless the doldrum was crossed at the same longitude, the varying atmospheric conditions should not be put down solely to the sun, or difference of December and May seasons.

Perhaps it is from want of the longitude that I am unable to understand "how low clouds from the south-east drove over north-east trades up to 15° north." All else is exceedingly satisfactory with the law of winds, on the supposition that the return crossing of the doldrum belt took place some hundreds of miles further west, and about half that distance farther south, than on the out journey.

If I may be allowed to digress a little, I would refer to the splendid travels by your correspondent, as published last Christmas under the title of "Seas and Skies in many Latitudes," which in some respects, I think, may be compared with the celebrated *Challenger* Expedition. But, singularly enough, while I am able to follow and accept all the author's research and information, I find myself diametrically opposed to his conclusions. Thus, to quote from p. 428, we have: "Hence we see the proof of the assertion that the trades and monsoons do not meet and force one another to rise, and flow back poleward, but that the two winds coalesce and form one great eastern current over the doldrum." To my mental capacity all the proof is the other way about. If the trades of both hemispheres do not ascend over the calm belt, what other escape or vent is there for them? I am aware that the Meteorological Section of the Krakatão Committee of the Royal Society also favour the idea of a great easterly current ever going west at a certain altitude over the doldrums, but so far as I can find out they do not tell us whence it cometh nor whither or how it goeth. In its circuit going west, we naturally look for its return from the east, and with the constant arrival of fresh winds *viâ* the trades of both hemispheres, it must accumulate if it does not flow back poleward quite as fast as it arrives, for we cannot entertain annihilation of atmosphere any more than of matter. If some other way of escape could be found, we should still have to face the question, Whence comes the supply to the "trades if not from the poles, and whence our prevailing south-westerly winds if not from over the doldrums"? E. FOULGER.

Liverpool, June 18.

P.S.—I do not call in question "the great easterly current over the doldrum," but rather consider its discovery as extremely interesting, it being just what a small school of meteorologists would expect; and it now appears to be left for them to supply a theory for the cause of the direction and also of the motive power of such an atmospheric passage, and possibly for that of the Krakatão dust. E. F.

Patches of Prismatic Light.

I AM curious to know if any of your readers observed the following phenomenon in the sky, and could give any information as to its nature.

When driving with two friends on Saturday evening, June 22, between 6.30 and 7 p.m., in the neighbourhood of Glatton, near Peterborough, we observed on either side of the sun (the sky being almost cloudless) two patches of prismatic light; they appeared to be of nearly the same size as the apparent disk of the sun, and distant from it a hand's span measured from little finger to thumb at arm's length. At the time there were a few light clouds about, but the prismatic patches were not projected on them, as the clouds passed occasionally in front of them, the patches meanwhile shining through the thinnest parts, and reappearing when the clouds had passed, clearly standing out against the sky. There was no appearance of a continuous arch, as in a rainbow, and, unlike a rainbow, the patches were on the same side of the sky as the sun. I may add that the phenomenon was seen by all three of us, and for half an hour after we first noticed it. C. S. SCOTT.

Glatton Hall, Peterborough, June 28.

A Chimpanzee's Humour.

IN a recent lecture Mr. Romanes is reported as having strongly denied the existence of even a trace of any feeling of the ludicrous in the renowned chimpanzee "Sally." It may be worth while to record a small fact observed by me lately, tending, I think, to favour an opposite view.

Being alone with a friend in Sally's house, we tried to get her to obey the commands usually given by the keeper. The animal came to the bars of the cage to look at us, and, adopting the keeper's usual formula, I said, "Give me two straws, Sally." At first she appeared to take no notice, although she had been eyeing us rather eagerly before. I repeated the request with no further result; but on a second or third repetition she suddenly took up a *large bundle* of straw from the floor and thrust it through the bars at us, and then sat down with her back to us. Our request was perhaps unreasonable, seeing that we had no choice morsels of banana with which to reward her. She did not, however, seem ill-tempered at our presumption, and the next instant was as lively as ever. It seems to me that her action on this occasion certainly came very near to an expression of humour. Rather sarcastic humour perhaps it was, but she certainly appeared to take pleasure in the spectacle of something incongruous, and this surely lies at the base of all sense of the ludicrous. HAROLD PICTON.

July 1.

PROF. HUXLEY AND M. PASTEUR ON HYDROPHOBIA.

ON Monday afternoon the meeting called by the Lord Mayor to hear statements from men of science with regard to the recent increase of rabies in this country, and the efficiency of the treatment discovered by M. Pasteur for the prevention of hydrophobia, was held at the Mansion House. Much excellent work was done. Several letters were read from those who were unable to attend. Among these letters was the following from Prof. Huxley:—

"*Monte Generaso, Switzerland, June* 25, 1889.

"MY LORD MAYOR,—I greatly regret my inability to be present at the meeting which is to be held, under your

Lordship's auspices, in reference to M. Pasteur and his Institute. The unremitting labours of that eminent Frenchman during the last half-century have yielded rich harvests of new truths, and are models of exact and refined research. As such they deserve, and have received, all the honours which those who are the best judges of their purely scientific merits are able to bestow. But it so happens that these subtle and patient searchings out of the ways of the infinitely little—of that swarming life where the creature that measures one-thousandth part of an inch is a giant—have also yielded results of supreme practical importance. The path of M. Pasteur's investigations is strewed with gifts of vast monetary value to the silk trader, the brewer, and the wine merchant. And this being so, it might well be a proper and a graceful act on the part of the representatives of trade and commerce in its greatest centre to make some public recognition of M. Pasteur's services, even if there were nothing further to be said about them. But there is much more to be said. M. Pasteur's direct and indirect contributions to our knowledge of the causes of diseased states, and of the means of preventing their occurrence, are not measurable by money values, but by those of healthy life and diminished suffering to men. Medicine, surgery, and hygiene have all been powerfully affected by M. Pasteur's work, which has culminated in his method of treating hydrophobia. I cannot conceive that any competently-instructed person can consider M. Pasteur's labours in this direction without arriving at the conclusion that, if any man has earned the praise and honour of his fellows, he has. I find it no less difficult to imagine that our wealthy country should be other than ashamed to continue to allow its citizens to profit by the treatment freely given at the Institute without contributing to its support. Opposition to the proposals which your Lordship sanctions would be equally inconceivable if it arose out of nothing but the facts of the case thus presented. But the opposition which, as I see from the English papers, is threatened has really for the most part nothing on earth to do either with M. Pasteur's merits or with the efficacy of his method of treating hydrophobia. It proceeds partly from the fanatics of *laissez faire*, who think it better to rot and die than to be kept whole and lively by State interference, partly from the blind opponents of properly-conducted physiological experimentation, who prefer that men should suffer rather than rabbits or dogs, and partly from those who for other but not less powerful motives hate everything which contributes to prove the value of strictly scientific methods of inquiry in all those questions which affect the welfare of society. I sincerely trust that the good sense of the meeting over which your Lordship will preside will preserve it from being influenced by these unworthy antagonisms, and that the just and benevolent enterprise you have undertaken may have a happy issue.

"I am, my Lord Mayor, your obedient servant,

"THOMAS H. HUXLEY.

"The Right Hon. the Lord Mayor,
Mansion House, E.C."

The following letter from M. Pasteur, dated Paris, the 27th ult., was read by Sir H. Roscoe:—

"Dear Colleague and Friend,—I am obliged by your sending me a copy of the letter of invitation issued by the Lord Mayor for the meeting on July 1. Its perusal has given me great pleasure. The questions relating to the prophylactic treatment for hydrophobia in persons who have been bitten and the steps which ought to be taken to stamp out the disease are discussed in a manner both exact and judicious. Seeing that hydrophobia has existed in England for a long time, and that medical science has failed to ward off the occurrence even of the premonitory symptoms, it is clear that the prophylactic method of treating this malady which I have discovered ought to be adopted in the case of every person bitten by a rabid animal. The treatment required by this method is painless during the whole of its course and not disagreeable. In the early days of the application of this method contradictions such as invariably take place with every new discovery were found to occur, and especially for the reason that it is not every bite by a rabid animal which gives rise to a fatal outburst of hydrophobia. Hence prejudiced people may pretend that all the successful cases of treatment were cases in which the natural contagion of the disease had not taken effect. This specious reasoning has gradually lost its force with the continually increasing number of persons treated. To-day, and speaking solely for the one anti-rabic laboratory of Paris, this total number exceeds 7000; or exactly, up to the 31st of May, 1889, 6950. Of these the total number of deaths was only seventy-one. It is only by palpable and wilful misrepresentation that a number differing from the above, and differing by more than double, has been published by those who are systematic enemies of the method. In short, the general mortality applicable to the whole of the operations is 1 per cent., and if we subtract from the total number of deaths those of persons in whom the symptoms of hydrophobia appeared a few days after the treatment—that is to say, cases in which hydrophobia had burst out (often owing to delay in arrival) before the curative process was completed—the general mortality is reduced to 0·68 per cent. But let us for the present only consider the facts relating to the English subjects whom we have treated in Paris. Up to May 31, 1889, their total number was 214. Of these there have been five unsuccessful cases after completion of the treatment, and two more during treatment, or a total mortality of 3·2 per cent., or more properly 2·3 per cent. But the method of treatment has been continually undergoing improvement, so that in 1888 and 1889, on a total of sixty-four English persons bitten by mad dogs and treated in Paris, not a single case has succumbed, although amongst these sixty-four there were ten individuals bitten on the head and fifty-four bitten on the limbs, often to a very serious extent. I have already said that the Lord Mayor in his invitation has treated the subject in a judicious manner, from the double point of view of prophylaxis after the bite and of the extinction of the disease by administrative measures. It is also my own profound conviction that a rigorous observance of simple police regulations would altogether stamp out hydrophobia in a country like the British Isles. Why am I so confident of this? Because, in spite of an old-fashioned and widespread prejudice, to which even science has sometimes given a mistaken countenance, rabies is never spontaneous. It is caused, without a single exception, by the bite of an animal affected with the malady. It is needless to say that in the beginning there must have been a first case of hydrophobia. This is certain; but to try to solve this problem is to raise uselessly the question of the origin of life itself. It is sufficient for me here, in order to prove the truth of my assertion, to remind you that neither in Norway, nor in Sweden, nor in Australia, does rabies exist; and yet nothing would be easier than to introduce this terrible disease into those countries by importing a few mad dogs. Let England, which has exterminated its wolves, make a vigorous effort, and it will easily succeed in extirpating rabies. If firmly resolved to do so, your country may secure this great benefit in a few years; but, until that has been accomplished, and in the present state of science, it is absolutely necessary that all persons bitten by mad dogs should be compelled to undergo the anti-rabic treatment. Such, it seems, is a summary of the statement of the case by the Lord Mayor. The Pasteur Institute is profoundly touched by the movement in support of the meeting. The interest which His Royal Highness the Prince of Wales has evinced in the proposed manifestation is of itself enough to secure its success. Allow me, my dear colleague, to express my feelings of affectionate devotion."

AN INDEX TO SCIENCE.

I HAVE lately received the "Sach Register" of the *Berichte der Deutschen Chemischen Gesellschaft*, 1868-87, in three volumes, indexing the twenty years of publication (thirty-six volumes). The work is admirably done, and is of inestimable value to the student of science generally. German scientific men and scientific Societies are far in advance of the English in the art of making the results of scientific research readily accessible. Witness the admirable "Bibliotheca Zoologica," by Engelmann and Carus, and still continued by Taschenberg; the "Sach Registers" to Liebig's *Annalen der Chemie*, 1832-83, to Poggendorff's (now Wiedemann's) *Annalen der Physik und Chemie*, 1824-87, and to the *Journal für Praktische Chemie*, 1833-87; and the "Repertorium Commentationum a Societatibus litterariis editarum," by Reuss, in sixteen quarto volumes, which last valuable production covers the whole ground down to the end of the last century.

The fact is very suggestive with regard to the English neglect of the scientific knowledge, experiment, and discovery locked up in the long series of English scientific journals to be found in our public libraries. The journals have usually, but not always, a short index at the end of each volume, obliging the student to occasionally spend days and weeks in searching through the series for what has been written on a subject he is investigating. The volumes accumulate on the shelves, and the experiments and investigations are repeated again and again.

The Royal Society, with a lively sense of the necessity for a remedy to the existing chaos, some twenty years ago commenced, and continues at intervals the issue of "A Catalogue of Scientific Papers contained in the Transactions of Societies, Journals, and other Periodical Works from the Year 1800." It is an author-list, and does not at all meet the requirements of the case. It necessitates a knowledge, by the inquirer, of the names of all the men who are likely to have written on the subject of inquiry. Life is not long enough for this. Librarians are occasionally of some assistance in the matter, but they often fail. What occurred lately has occurred to me often: I submitted to a chemist of some note the records of experiments published in 1820, which would have saved him many months of investigation of the same subject if a reference to the previous work had been accessible by index or by personal knowledge. It is the experience of all men of science that days may be spent in obtaining a reference to what may be read in five minutes, usefully or uselessly.

The Royal Society Catalogue originated from a suggestion of the late Joseph Henry, the Director, for thirty years, of the Smithsonian Institution (Washington) for the Increase and Diffusion of Knowledge, who said ("Smithsonian Miscellaneous Collections," vol. xxi. p. 295):—

"One of the most important means for facilitating the use of libraries (particularly with reference to science) is well-digested indexes of subjects, not merely referring to volumes of books, but to memoirs, papers, and parts of scientific transactions and systematic works. I know of no richer gift which could be bestowed upon the science of our own day than the provision of these. Everyone who is desirous to enlarge the bounds of human knowledge should, in justice to himself as well as to the public, be acquainted with what has been previously done in the same line."

Henry afterwards communicated with the British Association on the subject (in 1855). The Association appointed a Committee (Mr. Cayley, Mr. Grant, and Prof. Stokes), who reported:—

"The Committee are desirous of expressing their sense of the great importance and increasing need of such a Catalogue. . . . The Catalogue should not be restricted to memoirs in Transactions of Societies, but should comprise, also, memoirs in the Proceedings of Societies, in mathematical and scientific journals, &c. . . . The Catalogue should begin from the year 1800. There should be a Catalogue according to the names of authors, and *also a Catalogue according to subjects*."

The Committee succeeded in interesting the Royal Society of London in the undertaking, and that body ultimately assumed the direction of the work.

But they have achieved an instalment only of the recommendation of the distinguished Committee at whose suggestion they took action. They have produced an author-list, but the "Catalogue according to subjects" is wanting. All the subjects in the Royal Society's Catalogue should be at once placed under a subject-heading as well as under the author-heading in alphabetical arrangement, as near a concordance as possible by means of cross-references, and should be systematically continued and published annually. What has been done by Mr. Poole, of Chicago, for the great portion of English *general* periodical literature in publishing a subject-list, alphabetically arranged, of the articles contributed to 238 periodicals from 1802-81, and to 141 periodicals in the supplemental volume for 1882-87, should be done for all the scientific publications. The principle of the work is simple, and could be readily carried out. "The main purpose of this (Poole's) work was to meet the average wants of students, literary men, and writers for the press—in other words, to help general scholars, who are many, in preference to the few who give their whole attention to a single topic." From an experience of thirty-two years in libraries, I must say, with all due deference to Mr. Poole, that a subject-index of the scientific journals would be of vastly greater benefit to the community—material benefit, if he pleases. I ought, however, to add my meed of praise to the practical, sensible, and sufficient way in which the work that he attempted has been done.

An attempt at remedying our great literary defect was made by Robert Watt, 1819-24, when he added to the two quarto volumes of an alphabetical list of 40,000 authors in his "Bibliotheca Britannica, or General Index to British and Foreign Literature," an additional two volumes of an index of subjects. This has all the disadvantages of a first attempt. The study of bibliography was little known, and less cultivated, at the time. The book is almost entirely out of date. A great deal more may be said in favour of the combination of authors and subjects in one general catalogue, as successfully achieved by Lieutenant-Colonel Billings in the "Index Catalogue of the Library of the Surgeon-General's Office, United States Army," as far as the letter N, in nine volumes, royal octavo. This is a specimen of cataloguing almost perfect: every article, and every disease, and the complications of every disease, with the various organs, being catalogued and sub-catalogued with their cross-references.

The history of scientific research exhibits a continual tendency towards specialization; and as the sphere of the labourer has become limited each area of research has expanded, so that it has become essentially necessary that every subdivision of knowledge should be digested and arranged. With the co-operation of a few librarians, a subject-catalogue of all scientific literature might be readily undertaken by the Royal Society or the Society of Arts, the publications contained in the British Museum being marked by an asterisk or other sign. Or a system similar to that of the "Smithsonian Catalogue of Scientific and Technical Periodicals (1665-1882)" might be adopted, in which, by means of a check list at the end, it is shown in what American libraries all the periodicals may be found. A good portion of the work is done in such works as have been mentioned: in the indexes to the literature of special subjects in the Smithsonian collections, in the publications of the Harvard University, and in the indexes to the publications of Societies, such as the Chemical, Geological, Zoological, Linnean, Astronomical, Geographical, Engineers, Statistical, the Society of Arts, and the Royal Society, and in the indexes of various periodicals. These should be systematically arranged; the chaos should be organized and classified, to enable the man of science to find out at a glance all that has been published on any branch of his subject, and the work would be of value to the country.

The range of subject-headings should include everything relating to scientific and technical subjects. These would include (taking Comte's classification for convenience in the serial arrangement), Mathematics, Astronomy, Physics, Chemistry, Physiology (or what is commonly understood as Natural History, with the generic term of Physiology or Physio-Philosophy), and Social Physics (including Sociology). These subjects are clear, well defined, and well known to the librarians.

There is nothing so necessary as that scientific thought and method should be embodied, classified, and arranged, preliminary to its organization as a whole. It would quicken the slow process of improvement that has extended over a thousand years. It is wonderful that it should be necessary to say this in the nineteenth century. The need for organization in all departments of science is keenly felt; and the growth of Positivism in these latter days is one of the expressions of that need. Three centuries ago Bacon aimed at the organization of the sciences, holding that the sciences can be advanced only by combining them; that, as natural laws are invariable and uniform, "Physics being the mother of all science," so moral and civil philosophy could not flourish when separated from their roots in natural philosophy.

On national grounds it is necessary that this work should be done, for it is in the interest of the community generally, of the nation, that we should know what we possess. Public libraries and educational institutions are increasing; scientific experiment, discovery, and invention are increasing; and the demand for such a subject-catalogue will increase. Its value to the community would be inestimable. If it is thought advisable that the Royal Society or the Society of Arts should take the work in hand, the work should be subsidized by the Government, for the simple reason that it would be of national value. Scientific research is not so remunerative but that the student may fairly expect facility of access to the labours of those who have gone before. The want of a serviceable key to the vast body of scientific work contained in our literature is daily experienced by cultivators of science. There is a serious necessity that this material should be made more readily accessible for comparison, for verification, and for improvement. Much of it is a monument of shattered hopes, the unsuccessful efforts of poverty and despair; but all of it is suggestive to the earnest student.

No one Society or publisher can take the work in hand without Government support or benefaction. Attempts have been made, such as the attempt of the Royal Society, and that of Agassiz in his "Bibliographia Zoologiæ et Geologiæ," published by the Ray Society, which voluminous work, be it remembered, "was mainly compiled by the Professor for his own private use during the leisure moments of a life of almost incessant scientific research." In whatever hands the work may be placed, there is no doubt that the co-operation of the scientific Societies might be relied upon. With regard to the question of assistance from the Government, the following Minute of the Lords Commissioners of Her Majesty's Treasury, dated November 28, 1864, referring to the Royal Society's Catalogue, is very suggestive:—

"Having regard to the importance of the work with reference to the promotion of scientific knowledge generally, to the high authority of the source from which it comes, and to the labour gratuitously given by members of the Royal Society to its production, my Lords consider themselves justified in having the work printed at the cost of the public, with the understanding that, reserving such a number of copies for presentation as my Lords, in communication with the President of the Royal Society, may hereafter determine, the work shall be sold at such a price as may be calculated will repay the cost of printing.

"Their Lordships, however, desire it to be understood that the work shall go forth to the public under the authority of the Royal Society, by the exertions of whose members this important aid to the study of science has been produced."

J. TAYLOR KAY.

IRIDESCENT CRYSTALS.[1]

THE principal subject of the lecture is the peculiar coloured reflection observed in certain specimens of chlorate of potash. Reflection implies a high degree of discontinuity. In some cases, as in decomposed glass, and probably in opals, the discontinuity is due to the interposition of layers of air; but, as was proved by Stokes, in the case of chlorate crystals the discontinuity is that known as twinning. The seat of the colour is a very thin layer in the interior of the crystal and parallel to its faces.

The following laws were discovered by Stokes:—

(1) If one of the crystalline plates be turned round in its own plane, without alteration of the angle of incidence, the peculiar reflection vanishes twice in a revolution, viz. when the plane of incidence coincides with the plane of symmetry of the crystal. [Shown.]

(2) As the angle of incidence is increased the reflected light becomes brighter and rises in refrangibility. [Shown.]

(3) The colours are not due to absorption, the transmitted light being strictly complementary to the reflected.

(4) The coloured light is not polarized. It is produced indifferently whether the incident light be common light or light polarized in any plane, and is seen whether the reflected light be viewed directly or through a Nicol's prism turned in any way. [Shown.]

(5) The spectrum of the reflected light is frequently found to consist almost entirely of a comparatively narrow band. When the angle of incidence is increased, the band moves in the direction of increasing refrangibility, and at the same time increases rapidly in width. In many cases the reflection appears to be almost total.

In order to project these phenomena a crystal is prepared by cementing a smooth face to a strip of glass, whose sides are not quite parallel. The white reflection from the anterior face of the glass can then be separated from the real subject of the experiment.

A very remarkable feature in the reflected light remains to be noticed. If the angle of incidence be small, and if the incident light be polarized in or perpendicularly to the plane of incidence, the reflected light is polarized in the *opposite* manner. [Shown.]

Similar phenomena, except that the reflection is white, are exhibited by crystals prepared in a manner described by Madan. If the crystal be heated beyond a certain point the peculiar reflection disappears, but returns upon cooling. [Shown.]

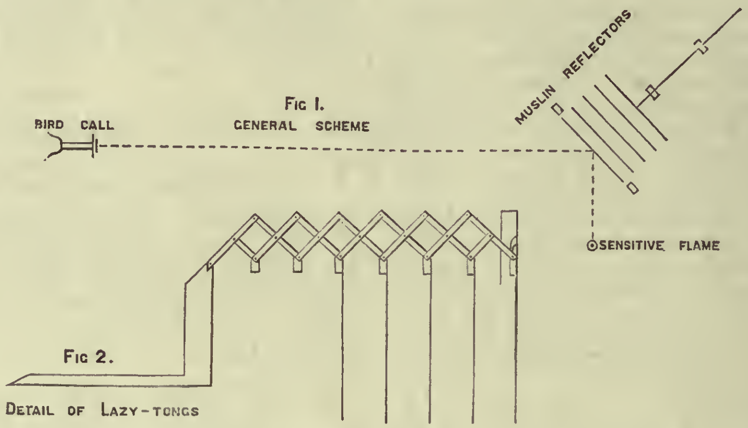
In all these cases there can be little doubt that the reflection takes place at twin surfaces, the theory of such reflection (*Phil. Mag.*, Sept. 1888) reproducing with re-

[1] Abstract of the Friday evening lecture delivered by Lord Rayleigh, F.R.S. at the Royal Institution on April 12, 1889.

markable exactness most of the features above described. In order to explain the vigour and purity of the colour reflected in certain crystals, it is necessary to suppose that there are a considerable number of twin surfaces disposed at approximate equal intervals. At each angle of incidence there would be a particular wave-length for which the phases of the several reflections are in agreement. The selection of light of a particular wave-length would thus take place upon the same principle as in diffraction spectra, and might reach a high degree of perfection.

In illustration of this explanation an acoustical analogue is exhibited. The successive twin planes are imitated by parallel and equi-distant disks of muslin (Figs. 1 and 2) stretched upon brass rings and mounted (with the aid of three lazy-tongs arrangements), so that there is but one degree of freedom to move, and that of such a character as to vary the interval between the disks without disturbing their equi-distance and parallelism.

The source of sound is a bird-call, giving a pure tone of high pitch (inaudible), and the percipient is a high-pressure flame issuing from a burner so oriented that the direct waves are without influence upon the flame (see NATURE, xxxviii. 208; Proc. Roy. Inst., January 1888). But the waves reflected from the muslin arrive in the effective direction, and if of sufficient intensity induce flaring. The experiment consists in showing that the action depends upon the distance between the disks. If the distance be such that the waves reflected from the several disks co-operate,[1] the flame flares, but for intermediate adjustments recovers its equilibrium. For full success it is necessary that the reflective power of a single disk be neither too great nor too small. A somewhat open fabric appears suitable.



It was shown by Brewster that certain natural specimens of Iceland spar are traversed by thin twin strata. A convergent beam, reflected at a nearly grazing incidence from the twin planes, depicts upon the screen an arc of light, which is interrupted by a dark spot corresponding to the plane of symmetry. [Shown.] A similar experiment may be made with small rhombs in which twin layers have been developed by mechanical force after the manner of Reusch.

The light reflected from fiery opals has been shown by Crookes to possess in many cases a high degree of purity, rivalling in this respect the reflection from chlorate of potash. The explanation is to be sought in a periodic stratified structure. But the other features differ widely in the two cases. There is here no semicircular evanescence, as the specimen is rotated in azimuth. On the contrary, the coloured light transmitted perpendicularly through a thin plate of opal undergoes no change when the gem is turned round in its own plane. This appears to prove that the alternate states are not related to one another as twin crystals. More probably the alternate strata are of air, as in decomposed glass. The brilliancy of opals is said to be readily affected by atmospheric conditions.

NOTES.

THE thirty-eighth meeting of the American Association for the Advancement of Science will be held at Toronto. On Tuesday, August 27, at noon, a meeting of the Council will be held at the Queen's Hotel, where will be the hotel head-quarters of the Association. On Wednesday, August 28, the first general session will begin at 10 o'clock in the forenoon in the Convocation Hall, University Buildings. After the adjournment of the general session, the several Sections will organize. In the afternoon the Vice-Presidents will give their addresses before their respective Sections, and in the evening there will be a general session, when the retiring President, Major J. W. Powell, will deliver his address. The sessions will continue until the Tuesday evening following, and on Wednesday morning, September 4, a meeting of the Council will be held. Saturday, August 31, will be devoted to excursions. The meeting will close with excursions extending to September 7. The general sessions and the meetings of the Sections will be held in the University Buildings, where also will be the offices of the local committee and of the permanent secretary during the meeting. *Science* states that arrangements have been made for a discussion in Section B on the "Relative Merits of the Dynamometric and Magnetic Methods of obtaining Absolute Measurements of Electric Currents." Prof. Thomas Gray, of the Rose Polytechnic Institute, will open the discussion with a paper on the subject, and he will exhibit one or more of Sir William Thomson's most recent forms of electric balance. Arrangements have been made by the local committee for the proper care and exhibition of instruments and specimens.

EFFORTS are being made by the American Association for the Advancement of Science to form a National Chemical Society, with its head-quarters at Washington. A meeting will be held to consider the matter during the session of the American Association at Toronto.

THE annual general meeting of the Marine Biological Association was held in the rooms of the Royal Society on the 26th ult. In the absence of Prof. Huxley, the chair was taken by Sir E. Bowman, and there were present, among others, Lord

[1] If the reflection were perpendicular, the interval between successive disks would be equal to the half wave-length, or to some multiple of this.

Walsingham, Prof. Flower, Prof. E. Ray Lankester, Admiral Sir Erasmus Ommanney, Mr. Gassiott, and Mr. Crisp. The report of the Council shows that a most satisfactory amount of work has been done at Plymouth since the Laboratory was opened at the end of June last year. Studies on various matters connected with the fishing industry are being carried on under the instructions of the Council, the most important being the study of the life-history of the common sole, by Mr. Cunningham, and an investigation on the sense-organs of fishes, by Mr. Bateson, which it is expected will throw new light on the bait question. Other naturalists, among whom Mr. Weldon may be specially mentioned, have utilized the Laboratory for carrying on independent biological researches, and much valuable work is being done. The Director of the Laboratory (Mr. Bourne) reports that the arrangements at the Laboratory are very satisfactory, and that the arrangements for the circulation of sea-water in the aquarium have worked well during the year. A substantial increase has been made in the library, a complete set of the *Challenger* publications, presented by the Lords Commissioners of the Treasury, being the most noticeable addition to its shelves. With one exception, the officers, Vice-Presidents, and Council, are the same as last year. Mr. Crisp has been compelled by increasing pressure of work to resign the post of Hon. Treasurer, which he has held with so much profit to the Association since its foundation. His place is taken by Mr. E. L. Beckwith, formerly a Prime Warden of the Fishmongers' Company, and Mr. Crisp retires to the Council *vice* Mr. W. Caine, M.P.

The Council of the Library Association has decided to hold the twelfth annual meeting of the Society in London during the second week in September. The Masters of the Bench of Gray's Inn have placed their Hall, for the third time, at the disposal of the Association.

On the night of June 15, about 10 p.m., there was a shock of earthquake, accompanied by a heavy subterranean rumbling, in the villages around Lake Arresö, in Denmark. Windows rattled and furniture oscillated, and in one place people ran out, believing that a powder-mill had exploded. The sound seemed to come from the east.

On June 12, at 11.16 p.m., a brilliant orange-coloured meteor was seen at Copenhagen. It radiated at τ Leonis, moving slowly towards β Virginis, where it burst into many fragments. It was accompanied by a tail, pointed at the end, about 2° in length.

In 1886 the Prince of Monaco, wishing to study the course of the Gulf Stream, threw into it some copper flasks from the *Hirondelle*. Three of these flasks have come ashore on the south coast of Iceland, two near the Ö Mountains, in the Rangárvall district, and the third at Flöj, in the Arnaes district.

It appears that the meteoric stone found in Scania, and acquired by Baron Nordenskiöld for the National Museum at Stockholm (p. 179), fell on April 6, and that its fall was accompanied by a red flash like lightning and a thunder-like detonation. It weighs 11 kilogrammes, and had made a hole 30 centimetres in depth; but, having recoiled, it lay on the level ground at the edge of the hole. The colour is greyish-black, and the fracture greyish-white. From a hasty analysis made by Herr A. Wingårdh, of Helsingborg, the chief mass appears to consist of manganese, in which are yellow and grey particles of metal. The meteorite seems to have been in a red-hot state, being covered with a glazed coating of fused metal half a millimetre in thickness.

Through the efforts of Dr. Filip Trybom, the Swedish Oyster-culture Society is attempting to acclimatize the American oyster, imported from Connecticut, in several places along the coast of the province of Bohus. The young oysters seem to thrive well.

The Norwegian cod-fishery in Finmarken this spring has been above the average, viz. 16,000,000 fish, against 9,000,000 last year. In Lofoten the fishery was a good average one, yielding 20,000,000 fish. Here the shoals congregated off the fishing-bank, in deep water, some five to ten miles from the shore.

On both sides of the Jösen Fjord, on the west coast of Norway, mountains rise perpendicularly to a height of several thousand feet. One morning, some days ago, stones and rocks, some of which are said to have been as large as a house, began to fall on the western side of the fjord. The avalanche continued for over two hours, accompanied by a noise heard 10 miles distant. A black cloud settled over the fjord, the water of which was in terrible commotion for many hours.

At a recent meeting of the Scientific Society of Copenhagen, Prof. Steenstrup gave an account of the results of his examination, last year, of the great mammoth deposit at Predmost, in Moravia. Dr. Wankel and Prof. Maschka, who have devoted much attention to the subject, are of opinion that the mammoths whose remains are found in this district were killed by man, and that their bodies were dragged thither to be eaten. Prof. Steenstrup, on the contrary, holds that the mammoths themselves sought the locality, and that they must have died from want of water, or from some other cause with which man had nothing to do. The splits in the remains are due, he thinks, to the action of water and sand, and afford no support to the notion that the knuckles were cleft for the sake of the marrow. It is certain that some of the bones have been exposed to the action of fire; but Prof. Steenstrup maintains that the traces of fire may be due to the fact that fires were at one time lighted upon them. On some of them, decorative lines have been scratched, but these may have been made long after the mammoth was extinct in Moravia. The lines, according to Prof. Steenstrup, are identical with the ornamentation of pottery of the Neolithic Age.

Mr. Bosworth-Smith, in a report on the Kolar Gold Field, in Southern India, issued by the Madras Government, records some "finds" of old mining implements, old timbering, fragments of bones, an old oil lamp, and broken pieces of earthenware, including a crucible, the remains of ancient mining operations. He expresses astonishment at the fact that the old miners were able to reach depths of 200 or 300 feet through hard rock, with the simple appliances at their command; and he describes the method which he thinks they pursued, sinking pits at short distances from each other, and leaving a "bar" between to prevent falling in.

Herr Richard Andree has issued a new series of his ethnographical parallels and comparisons. Ten years ago the first series appeared, and now, as then, the system pursued is to select a particular topic and then range over the whole literature of ethnology in search of references to the particular subject and collate them, until, finally, an ethnological monograph on the topic in question is produced. This method of work is of course exceedingly laborious, but it has the merit of being exhaustive and effective. Single subjects are thus worked out, and the results published in some scientific periodical; as soon as one is concluded another is taken up, and so on. By and by material for a volume is accumulated, the various subjects are brought up to date, and the public gets a work on ethnology, conceived on a novel plan, and full of interest. Each topic is pursued all over the earth, from country to country, with marvellous industry. The present volume deals with such topics as red hair, albinos, games, masks, marks of property, superstitions connected with the chase, "tree and man," circumcision, drawing amongst primitive peoples, thunderbolts, money for the dead, emotional expressions and gestures, demoniacs and mental disorders, &c.

THE latest number of the Journal of the Asiatic Society of Bengal (vol. lvii. part ii. No. 4) contains, among other papers, some interesting notes, by Prof. J. Wood Mason, on objects from a Neolithic settlement recently discovered by Mr. W. H. P. Driver, at Ranchi, in the Chota Nagpore district. Among the objects described, and represented on plates, are some chisel-edged arrow-heads similar to those which have been found in Egyptian tombs—in several cases still secured by bitumen to the shaft—and on Neolithic sites in different parts of Europe, including the British Isles.

THE Trustees of the Indian Museum, Calcutta, have issued the first number of a Catalogue, by Prof. J. Wood Mason, of the Mantodea, with descriptions of new genera and species, and an enumeration of the specimens, in the collection of the Museum. This number consists of 48 pages, and is illustrated with 34 woodcuts.

WE have to welcome the first report on Greek climate published in Greek by Prof. Sp. E. Marinos, of Corfu. Some meteorological reports relating to Greece have at times appeared in the Proceedings of the Society Parnassus at Athens, but these have mostly emanated from the late Baron Sina's observatory, directed by Dr. Schmidt, have related to Attica, and have been published in German. The present paper is a short notice of the records of Corfu for 1887 and 1888.

THE Annual Report of the Director of the Mauritius Observatory for the year 1887 shows that the mean temperature of the year was 1°·4 below the average, and that the temperature was below the average in every month, the greatest deviation being 2°·5 in August. No storm passed near the island, which has not been visited by a hurricane since March 1879. During the year 1887 the velocity of thirty miles an hour was reached only once, in June. Rainfall is recorded at seventy-five stations, and Dr. Meldrum states that the comparisons made during the last ten years show conclusively that there is a close connection between the rainfall and the malarial fever on the low lands.

IN his last Meteorological Report for India, Mr. Elliot, referring to sun-spots and weather in India—a subject which has been frequently mentioned in these Reports—says:—"So far as India is concerned, it would appear that it is the period of minimum sun-spots which is associated with the largest and most abnormal variations of meteorological conditions and actions. Thus, exceptionally heavy snow fell in the North-West Himalayas in the winter of 1866, and again in 1876 and 1877. The latter is to some extent described in the Annual Reports on the meteorology of India for these two years. Again, the most striking and disastrous famines of recent years in India have occurred near the period of minimum sun-spots; as, for example, the Orissa famine of 1866, the Behar famine of 1874, and the Madras famine in 1876–77. Similarly, there is a clearly marked tendency for the largest and most intense cyclones to occur shortly before the period of minimum sun-spots; as, for example, the great Calcutta cyclone of 1864, in which 60,000 people were drowned by the storm-wave, and the still larger Backerganj cyclone of 1876, in which 100,000 lives were lost by drowning. As we are now approaching or passing through the same phase of the sun-spot period, it is interesting to inquire whether there are any large abnormal variations common to the present period of minimum sun-spots, and the previous corresponding periods of 1865–66 and 1876–77."

THE Manchester Microscopical Society has published its ninth Annual Report, with a Presidential address, by Prof. Milnes Marshall, on "Inheritance," and a lecture, by Prof. W. Stirling, on "Electrical Phenomena in Animals." The volume also contains many papers and communications by members of the Society.

THE new number of the *Mineralogical Magazine* opens with a valuable paper, by Mr. Fletcher, on crystals of percylite, caracolite, and an oxychloride of lead (daviesite) from Mina Beatriz, Sierra Gorda, Atacama. The number also contains, besides some shorter papers, an article by Prof. Judd, on the processes by which a plagioclase felspar is converted into a scapolite.

THE ninth part of Cassell's "New Popular Educator" has just been published. It contains a good map of the world, showing isothermal lines, and the distribution of races and vegetation.

THE first twelve numbers of *Life Lore*, a monthly magazine of biology, have now been collected in a volume, a copy of of which has been sent to us. The volume contains many brightly-written articles, and should do much to excite the interest of young readers in the more popular aspects of biological science.

PROF. MILTON WHITNEY, Professor of Agriculture and Vice-Director of the Experiment Station of the University of South Carolina, has devised a modification of Six's thermometer for soil temperature. The bulb is 6 inches long, protected by a metallic cylinder perforated with many holes, and is buried in the soil, so that the bulb shall extend from 3 to 9 inches below the surface of the soil—the maximum and minimum scale being of course above the soil, and arranged very much as in the ordinary Six's form. The long bulb allows a good height of scale, while it is narrow enough to respond readily to changes of temperature. In a series of readings the instrument gives exactly the mean of the readings of a 3-, 6-, and 9-inch thermometer of the usual form placed beside it at these respective depths in the soil, besides recording the maximum and minimum temperatures. This length of bulb and depth in the soil was decided on, as it is assumed to be the depth which contains most of the roots of the ordinary cultivated plants. The instrument need only be read once a day, and saves an immense amount of calculation and tabulation attending the tri-daily readings of the 6 to 8 instruments comprising the set of the usual form.

THE Russian Geographical Society is now publishing its Memoirs in parts, each of which contains a separate paper, and is circulated as soon as the paper has been printed. The last parts of the "Memoirs of General Geography" contain the following interesting papers:—"The Agricultural Meteorological Observations in Russia in 1885 and 1886," by Dr. Woeikof, being the observations made at fifty-one different stations in accordance with a scheme issued by the Geographical Society; "On Barometrical Observations at Distant Stations and during Journeys," by R. N. Savelieff; "On the Measures taken in Western Europe for consolidating Shifting Sands, and growing Bushes and Trees upon them," by S. Rauner; and "On the Comparison between Normal Barometers of the Principal Meteorological Stations of Europe," by P. Brounow. It appears that the corrections to be applied to the pressures shown by the barometers of the following stations are as follows (the normal barometer at St. Petersburg being taken for zero):—Berlin, − 0·02 millimetres; Hamburg, − 0·39; Utrecht, − 0·32; Brussels, + 0·23; Paris, + 0·11; Sèvres (Bureau International des Poids et Mesures), + 0·10; Zurich, − 0·06; Vienna, + 0·11.

IN a communication lately made to the Russian Geographical Society, General Annenkoff insisted upon the possibility of the

Transcaspian region being colonized. He pointed out that the girdle of loess which encircles the mountains is quite as productive as the loess in China. The climate is, of course, quite different—not so much on account of the want of rain (the amount of rain at Merv, during the winter months of 1885-86, reached the very high figure of 1654 millimetres), as on account of its absence during the summer months. But the rivers of the region—the Amu, the Tejen, and the Murghab—if their waters were utilized for irrigation, instead of being lost in the sandy deserts, would supply the amount of water necessary for irrigating immense tracts of land. All that is wanted to make of Central Asia a rich oasis of agriculture is human labour and human intelligence. The soil, when irrigated, is not inferior in fertility to the fertile loess fields of China.

THE Inspector-General of Indian Affairs in Canada, in his Report for the past year, urges the continuation of the policy of amalgamating the Canadian Indians as far as possible with the surrounding population, especially by inducing them to adopt agriculture and handicrafts, so that they may acquire a taste for a settled life. The Indians of the Province of Ontario seem to be most successful in reaching this end, and in all cases the tribes show an increase in numbers. There were no serious disturbances during the year, and the only excitement was produced amongst the natives on the Upper Skeena, in British Columbia, owing to the arrest and execution of one of their number for murder. The total number of Indians in the Dominion is given at 124,589; of these, 37,944 are in British Columbia, 26,368 in Manitoba and the North-Western Territory, 17,700 in Ontario, 12,465 in Quebec, 8000 in Athabasca, 7000 in the Mackenzie district, 4016 in Eastern Rupert's Land, 4000 on the Arctic coasts, 2145 in New Scotland, 2038 in the Peace River district, 1594 in New Brunswick, 1000 in the interior of Labrador, and 319 in Prince Edward's Island. 6127 Indian youths and girls attend the schools provided for them, nearly half the pupils belonging to Manitoba and the North-Western Territories; of the 956,000 dollars appropriated for native affairs, the same districts received 876,000 dollars. 21,344 acres of the land set apart for the improvement of Indians were alienated during the year, and 458,283 acres still remain.

THE additions to the Zoological Society's Gardens during the past week include a Black-headed Lemur (*Lemur brunneus* ♂) from Madagascar, presented by Mr. Charles C. Stewart; four Angora Goats (*Capra hircus*, var., ♂ ♀ ♀ ♀) from Barrol, Cape Colony, presented by Messrs. Theophilus Bros.; a Two-spotted Paradoxure (*Nandinia binotata*) from West Africa, presented by Mr. Philip Lemberg; a Ring-necked Parrakeet (*Palæornis torquatus*, yellow var.) from India, presented by Colonel C. Swinhoe; a Common Kestrel (*Tinnunculus alaudarius*), British, presented by Master W. P. Teil; two Goshawks (*Astur palumbarius*), European, deposited; a —— Lemur (*Hapalemur*, sp. inc.) from Madagascar, two Undulated Grass Parrakeets (*Melopsittacus undulatus*) from Australia, purchased; a Thar (*Capra jemlaica*), two Mule Deer (*Cariacus macrotis* ♂ ♂), three American Wild Turkeys (*Meleagris gallo-pavo*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL SOCIETY OF THE PACIFIC.—The second of the publications of this Society has appeared, containing an address delivered before the Society on March 30, 1889, by the President, Prof. Holden, on "The Work of an Astronomical Society." Prof. Holden sketched the state of astronomical science in England immediately prior to the foundation of the Royal Astronomical Society, and quoted freely from its first paper as showing the spirit which should inspire similar organizations elsewhere. The points Prof. Holden especially put forward as to be attained by the new body were the publication of observations, the guidance of amateur workers, especially those who were skilled photographers, the instruction of learners, the formation of an astronomical library, together with all the advantages resulting from free discussion, and the friendly interchange of ideas. The address was able, straightforward and unpretentious, and concludes with the recommendation, "Whatever we do, let us do thoroughly. Whatever we say, let it be well considered. Let us clearly understand the objects for which we are organized, and let us pursue these with entire confidence." With these principles for its guidance, the new Society will not fail of an honourable and useful career.

A NEW COMET.—A new comet was discovered by Mr. E. E. Barnard (Lick Observatory) on June 23·9499 G.M.T., R.A. 20° 13′ 21″, N.P.D. 51° 9′ 16″; daily motion, R.A. +1° 6′, N.P.D. −0° 34′. The comet was only faint.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 JULY 7–13.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on July 7

Sun rises, 3h. 55m.; souths, 12h. 4m. 40·0s.; daily increase of southing, 9·5s.; sets, 20h. 15m.: right asc. on meridian, 7h. 7·3m.; decl. 22° 33′ N. Sidereal Time at Sunset, 15h. 19m.

Moon (Full on July 12, 21h.) rises, 13h. 46m.; souths, 19h. 16m.; sets, 0h. 34m.*: right asc. on meridian, 14h. 19·8m.; decl. 8° 49′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian h. m.	Declination on meridian ° ′
Mercury..	2 49	10 40	18 31	5 42·3	19 44 N.
Venus.....	1 18	8 51	16 24	3 53·4	16 46 N.
Mars......	3 21	11 41	20 1	6 43·5	23 55 N.
Jupiter....	19 9	23 3	2 57*	18 7·6	23 18 S
Saturn....	6 55	14 24	21 53	9 26·8	16 14 N.
Uranus...	12 33	18 4	23 35	13 7·1	6 28 S.
Neptune..	1 16	9 5	16 54	4 7·6	19 18 N.

* Indicates that the setting is that of the following morning.

July.	h.	
10	8	Venus at greatest elongation from the Sun, 46° west.
11	14	Jupiter in conjunction with and 0° 52′ south of the Moon.
12	10	Mercury at greatest elongation from the Sun, 21° west.
12	—	Partial eclipse of the Moon; first contact with shadow, 19h. 43m.; middle of eclipse, 20h. 54m.; last contact with shadow, 22h. 5m. In England the Moon rises generally before the middle of eclipse.

Saturn, July 7.—Outer major axis of outer ring = 37″·4; outer minor axis of outer ring = 9″·2: southern surface visible.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	July 9,	21 25	*m*
S Ursæ Majoris	12 39·1	61 42 N.	,, 11,		*m*
W Ophiuchi	16 15·4	7 26 S.	,, 8,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 8,	0 5	*m*
			,, 13,	0 51	*m*
X Sagittarii	17 40·6	27 47 S.	,, 7,	23 0	*M*
Y Sagittarii	18 14·9	18 55 S.	,, 11,	3 0	*m*
β Lyræ	18 46·0	33 14 N.	,, 12,	1 0	*M*
R Aquilæ	19 1·0	8 4 N.	,, 12,		*m*
S Sagittæ	19 51·0	16 20 N.	,, 10,	0 0	*m*
R Sagittæ	20 9·0	16 23 N.	,, 12,		*m*
V Cygni	20 37·7	47 45 N.	,, 10,		*M*
T Vulpeculæ	20 46·8	27 50 N.	,, 13,	2 0	*m*
R Vulpeculæ	20 59·5	23 23 N.	,, 10,		*m*
δ Cephei	22 25·1	57 51 N.	,, 13,	22 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near 96 Herculis	270	21 N.	Very slow.
	280	14 S.	Slow.
,, π Cygni	330	36 N.	Swift; red streaks.
,, ι Andromedæ	352	40 N.	Swift.

OPTICAL TORQUE.[1]

I.

SEVENTY-EIGHT years have elapsed since the first discovery, by Arago, of the remarkable chromatic effects produced by slices of quartz crystals upon light, previously polarized, which was caused to traverse them. These effects were shown, one year later, by Biot, to be caused by a peculiar action of the quartz in rotating the plane of polarization; the amount of the rotation being different for lights of different colours. Ever since then, the rotation of the plane of polarization of light has been a topic familiar to physicists. It has stimulated the devotee of research to an endless variety of experiments and suggestive speculations: it has lured on the mathematician to problems which tax his utmost skill: it has afforded to the lecturer an array of beautiful and striking illustrations. Here, in this place, made classical by the researches and expositions of Thomas Young, of Michael Faraday, and of William Spottiswoode, and last, but not least, by the labours of those eminent men whom we rejoice still to number amongst the living—here, I say, on this classic ground, the rotation of the plane of polarization of light is almost a household word, and its phenomena are amongst the most familiar. We know now that not only certain actual crystals, such as quartz, bromate of soda, and cinnabar, rotate the plane of polarization, but that many non-crystalline bodies—liquids, such as turpentine, oil of lemons, solutions of sugar and of various alkaloids, and even certain vapours, such as that of camphor—possess the same property.

In 1845, at the very culminating point of his unique career of research, Faraday opened a new field of inquiry, linking together for the first time the science of optics with that of magnetism, by his discovery that the rotation of the plane of polarization of light could be effected by the application of magnetic forces. This effect he observed first in his peculiar "heavy-glass," when it lay in a powerful magnetic field. Subsequently he found other bodies to possess similar properties: some of these being magnetic liquids, such as solutions of iron, others being diamagnetic. Time will only permit me in passing to refer to the researches of Verdet, and those of Lord Rayleigh and of Mr. Gordon upon the numerical values of the magneto-optic rotation in these substances. H. Becquerel has extended them to gases, and has shown how the magnetism of the earth rotates the plane of polarization of the light which, previously polarized by reflection from the aërial particles which give the sky its "blue," passes earthward through the oxygen of the air.

Other experimenters have dealt with the rotatory effects (whether crystalline, molecular, or magnetic) in relation to lights of different colours, and have studied the dispersion which arises from the greater actual angle of optical torsion which is produced upon waves of short wave-length (violet and blue) than that which is produced under the influence of equal rotatory forces upon the waves of longer wave-length (red and orange). It has also been demonstrated that the plane of polarization of waves of invisible light, whether those of the infra-red, or those of the ultra-violet species, if they have been previously polarized, can be rotated just as can that of waves of visible light.

In 1877, Dr. Kerr, of Glasgow, discovered a point which Faraday had sought for, but fruitlessly—namely, that in the act of reflection at the pole or surface of a magnet, there is a rotation of the plane of polarization of light. This discovery was completed in 1884 by Kundt, of Strasburg, by the further demonstration, also dimly foreseen by Faraday, that a magneto-optic rotation of the plane of polarization is caused by the passage of previously polarized light through a normally magnetized film of iron so thin as to be transparent.

Lastly, in this brief enumeration, we were shown a month ago, by Oliver Lodge, how the magnetic impulses generated by the rapid oscillatory discharges of the Leyden jar can produce corresponding rapid oscillatory rotation in the plane of polarization of the waves of previously polarized light.

You will not have failed to notice the cumbrous phrase which, whether in speaking of the purely optical effects (of quartz, or sugar, or turpentine), or in speaking of the magneto-optic effects of more recent discovery, I have employed to connote a very simple fact. You may have wondered that any lover of simple English speech should indulge in such sesquipedalian words.

Of course, at this period of the nineteenth century it is no longer open to debate that light consists of waves. The plane of polarization of the waves of light is the plane of polarization of the light itself. The rotation of the plane of polarization is the rotation of the polarized waves, and therefore of the polarized light itself. Yet I must draw attention to the fact that in all the array of discoveries which I have enumerated, that which had been observed was the rotation—whether by crystalline, molecular, or magnetic means—not of natural light, but of light which had by some means been previously polarized. It was not known to Arago or to Biot, to Fresnel, to Faraday, nor even to Spottiswoode or to Maxwell, that natural unpolarized light could be rotated. They may have inferred so, but it was not in their time even demonstrable that a beam of circularly-polarized light could be rotated upon itself in the same sense as that in which a beam of plane-polarized light could be rotated.

That light of any and every kind, however polarized or devoid of that which is called polarization, can be, and in fact is, rotated when it passes across a slice of quartz or along a magnetic field, is a wider generalization of more recent date; but one of the reality of which I hope to convince you before the warning finger of the clock puts a period to my discourse.

In order the better to enable this audience to comprehend the ultimate significance of this discovery, I must claim the indulgence of those amongst them who are already familiar with the subject of the polarization of light, whilst I go back to the most simple elementary matters. Having illustrated the fundamental facts about the plane of polarization of light and its twisting, I shall then go on to methods of precisely measuring the amount of optical torsion produced by the various substances under various conditions. And after dealing with the magnetic as well as the crystalline and molecular methods of producing optical torsion in the case of light that has been previously polarized into a given plane, I shall be in a position to speak of the nature of the torque,[1] or twisting force, which in the several cases produces the torsion; and shall finally endeavour to indicate the scope of the researches by which it is now definitely ascertained that the very same optical forces which are capable of impressing a rotation upon light which has been artificially polarized into a definite plane are also capable of impressing a rotation upon natural, non-polarized light.

At the outset, to elucidate to any who may not comprehend the meaning of the term polarization as applied to wave-motion, I will show a simple apparatus, constructed from my designs by Mr. Groves. In this there are two sets of movable beads, fixed upon stems which pass into a box containing a piece of mechanism actuated by means of a handle. These beads, when I turn the handle, oscillate to and fro in definite directions, and, by their successive motions, give rise to progressive waves. One set of beads, tinted red, executes movements in a plane inclined 45° to the right, another set, silvered, simultaneously executes movements at 45° to the left. There are therefore here two waves, the planes of polarization of their movements being at right angles to one another. Their velocity of march is equal; but in this model, as a matter of fact, their phases differ by one-quarter—that is to say, each successive wave of the one set is always a quarter of a wave-length behind the corresponding wave of the other set. [Model exhibited.]

Now, in the case of waves of natural light from all ordinary sources—sun, stars, candles, gas-flames, or electric light—the waves emitted are not found to be polarized. That is to say, their motions are not executed in any particular plane, nor even in any particular path of any kind; they appear to be absolutely heterogeneous at least so far as this, that no vibration of the millions of millions emitted in a second of time is followed by more (on the average) than about 50,000 vibrations of a similar sort, executed along a similar path—the plane of the polarization, if any, changing after the lapse of such an incredibly short time that for most purposes the vibrations in different directions are as inextricably mixed as if they had all been simultaneously jumbled up. Since, then, natural light is non-polarized or miscellaneous, the production of polarized light must be brought about by the employment of polarizing apparatus or agents which will so operate on or affect the mixed waves as to bring their vibrations into one direction—or, what amounts to the same thing, transmit the light whilst destroying or absorbing those

[1] A Discourse delivered at the Royal Institution, May 17, 1889, by Prof. Silvanus P. Thompson.

[1] The convenient term *torque* was first proposed by Prof. James Thomson, of Glasgow, for the older and more cumbrous phrase "moment of couple," or "angular force." Its general acceptance by engineers justifies the extension of the term to optics. As a mechanical torque is that which produces or tends to produce mechanical torsion, so optical torque may be defined as that which produces or tends to produce optical torsion.

parts of the vibrations which are executed *across* the desired line of vibration. So we have *polarizers* consisting of tourmaline slices; oblique bundles of thin glass plates; black-glass reflectors; and Nicol prisms cut from calc-spar. About the two latter I may be permitted a passing word presently. These objects polarize, *i.e.* turn into one plane, the vibrations of light falling upon them. A rough mechanical illustration may here be permitted me. A long india-rubber cord is passed through the open ends of a box provided with vertical partitions. Fig. 1 shows the arrangement. These partitions confine the motion of the cord, and effectually polarize the vibrations which I now impart to the cord by shaking the end of it to and fro. If the partitions are vertical,

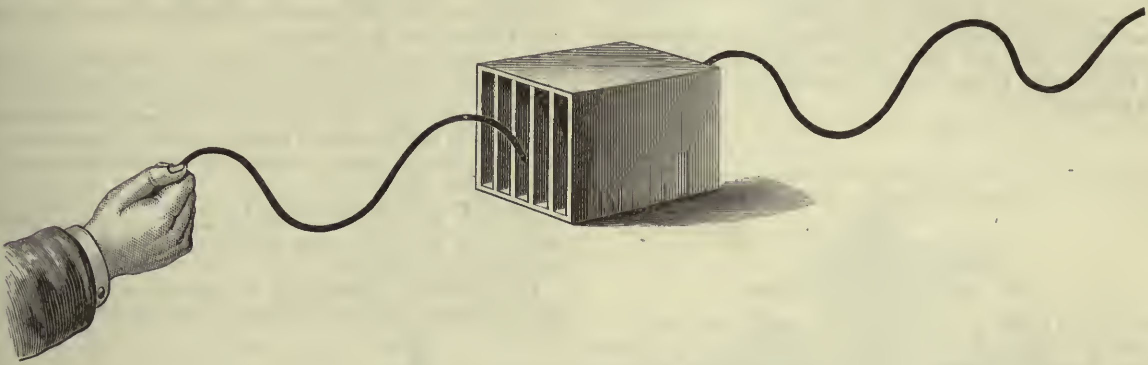


Fig. 1.—Box with partitions to illustrate polarization of vibrations.

the box polarizes, into vertical vibrations only, the miscellaneous vibrations which are sent to it. If rotated until its partitions are horizontal, it polarizes the vibrations into a horizontal position.

Let us now turn to the optical analogue of this experiment. The large Nicol prism which I introduce into the field of the electric-light lantern, polarizes the light, so that the vibrations are executed simply in an up-and-down direction. Your eye will not detect this, the motions being millions of times too rapid. To detect the direction, an analyzer is necessary. For this purpose a second apparatus of the same sort is used, for then, by crossing the positions of the two, the whole of the light is cut off; the second Nicol prism, if set so as to transmit only horizontal vibrations, cutting off the vertical vibrations that are sent through the first prism. So, whilst the first prism serves as

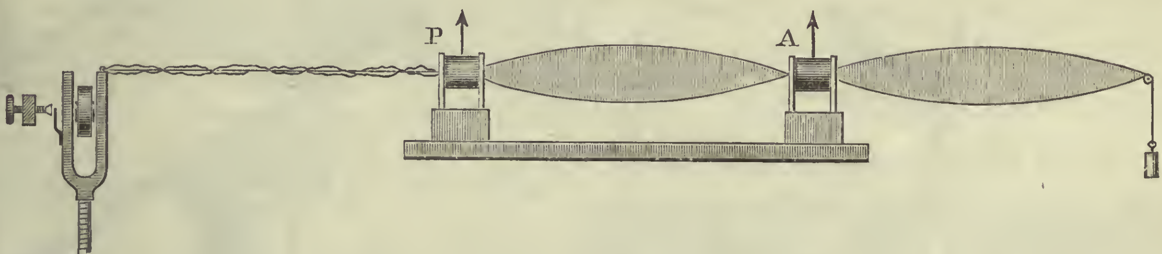


Fig. 2.—Acoustic model illustrating polarization of vibrations. P, the polarizer; A, the analyzer.

a polarizer, the second serves as an analyzer to detect by cutting them off when turned to the proper position, the direction of the polarization which had been previously impressed by the first prism.

Here I may illustrate the action of the analyzer for determining the plane of polarization of the vibrations, by the extinction which it produces when turned to the crossed position. For this purpose I have refined upon the box with partitions, using instead parallel plates of glass mounted in wooden cylinders, whilst for the cord swung by hand I am using Prof. Schwedoff's device, and am producing the vibrations in this silken cord by means of an electrically-driven tuning-fork (Fig. 2). At the first nodal point of the stretched cord a pair of parallel glass plates acts as a polarizer, the cord from that point vibrating in the

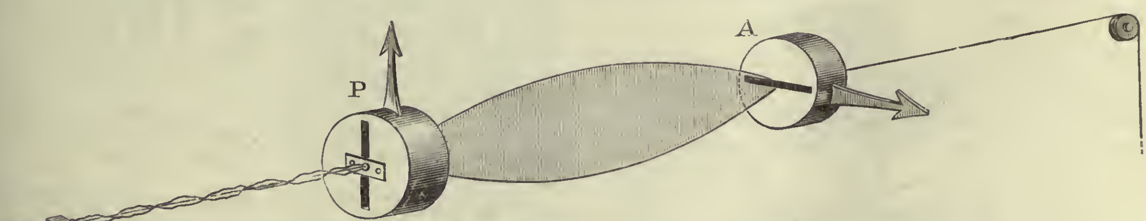


Fig. 3.—Vibrations cut off by turning the analyzer A at right angles to the polarizer P.

plane thus imposed upon it. I can alter this plane at will by rotating the polarizer. This polarizer, P, consisting of a pair of glass plates, is mounted in a cylindrical mount, and is provided with an arrow to indicate their direction. If now at any subsequent node I introduce a second such device, it will act as an analyzer, A. This excellent suggestion is due to M. Macé de Lepinay. In Fig. 2 the polarizer and analyzer are parallel. You see (Fig. 3) how the vibration is extinguished when the positions of analyzer and polarizer are crossed. Half a degree of error in the position of the analyzer produces something less than perfect extinction of the vibrations. Hence it is possible, by this analyzer, to determine the plane of the vibrations to the accuracy of half a degree. I should say that the whole of this model has been constructed by my assistant, Mr. Eustace Thomas.

Now let me show you the optical effect which corresponds to this. Placing a second Nicol prism as analyzer in the path of the polarized waves, I turn it to the position where it cuts off the polarized light. The "*dark field*" so produced by the crossed Nicol prisms corresponds to the motionless cord beyond the crossed analyzer of the acoustic apparatus.

Returning for a moment to two well-known forms of polarizing apparatus, viz. the black glass reflector and the Nicol prism, I may be permitted to refer to some recent attempts to improve upon these devices.

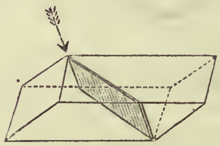


FIG. 4.—Nicol prism: original form.

The Nicol prism, as is well known, consists of a rhomb of Iceland spar cut into two pieces, which are reunited by a film of Canada balsam. As originally devised, it had oblique end faces (Fig. 4), and a comparatively narrow angle (19°) of aperture. These may be noticed in the small example which I here exhibit, which is an original constructed by William Nicol himself. It also has the disadvantage of giving a field in which the directions of the planes of polarization are not strictly parallel to one another throughout its whole extent. Consequently there is never complete extinction of light all over the field at one time. Hartnack and others have attempted to remedy this by giving the prism a different form and using other materials than Canada

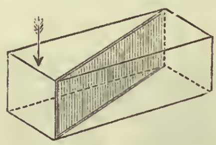


FIG. 5.—S. P. Thompson's modification of the Nicol prism.

balsam. I have from time to time made many attempts to improve upon the original construction. First, I have made the end faces principal planes of section (Fig. 5); secondly, I have made the axis of vision cross the crystallographic axis at right angles, so getting a flatter field, a shorter length, a wider angle, and less loss of light by reflection. Mr. Ahrens, the prism-cutter, on whose able assistance I have relied during the last six or seven years in cutting these prisms, has aided me with his ingenuity in devising a method of cutting up the spar so as to give these advantages with a minimum waste of material. He has further devised a method of putting a polarizing prism together in three instead of two pieces—illustrated in the diagram (Fig. 6)—which

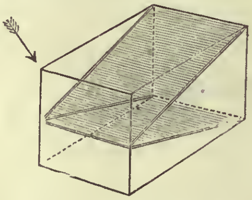


FIG. 6.—Ahrens's triple prism.

gives a still wider angle. The prism which I shall use as analyzer in the next experiments is one of these forms.

Unfortunately at present there is a spar-famine, pieces of Iceland spar of a size and purity suitable for the making of large polarizers such as that I employ being not now procurable at any price. To avoid the excessive cost of large Nicols I have lately got Mr. Ahrens to construct for me a large reflection-polarizer, on the plane of Delezenne, but modified by Mr. Ahrens in detail. In this prism the light is first turned to the proper polarizing angle by a large total-reflection prism of glass, and then reflected back, parallel to its original path, by impinging upon a mirror of black glass covered by a single sheet of the thinnest patent plate-glass to increase the intensity of the light. This form of polarizer, depicted in Fig. 7, is quite equal for projection purposes to a Nicol prism of equal aperture, and is much less costly. This one has 2½ inches clear aperture.

Having so far reviewed the apparatus for polarizing and analyzing, I will return to the apparatus set with its prisms crossed, so that the analyzer completely extinguishes the polarized light emitted from the polarizer.

If in the space between polarizer and analyzer anything be introduced which can either resolve obliquely the polarized vibrations or twist them bodily round, then there will not be complete extinction; the amount of light passing the analyzer depending in the one case on the obliquity of the resolution, in the other upon the degree to which the vibrations are twisted or rotated upon themselves.

The effect of oblique resolution I may illustrate by introducing a slice of tourmaline between the crossed Nicols, and rotating it till it stands at 45°; or, in the acoustic model, by introducing an oblique pair of guide-pins.

The other case—namely, that of producing a bodily twist of the vibrations, rotating the plane of polarization around the

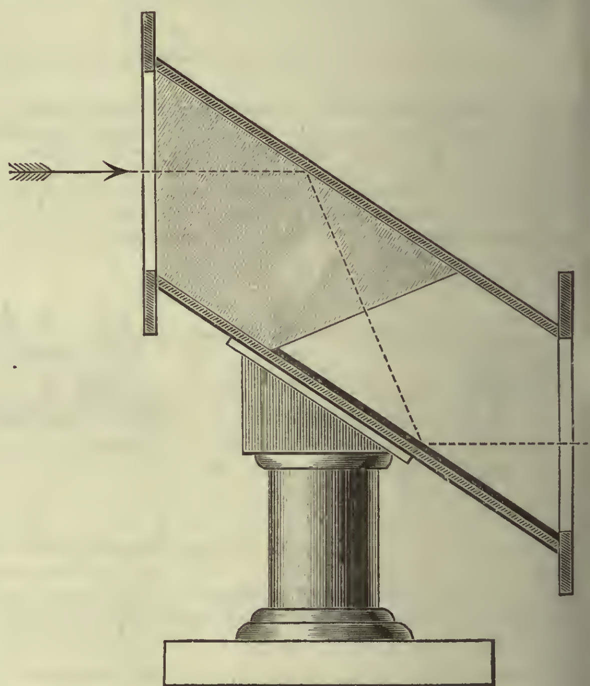


FIG. 7.—Ahrens's reflecting polarizer.

path of the wave—is not so easily illustrated by the model. But it is optically perfectly simple: all that is requisite is to introduce between the crossed Nicols a thin slice of that crystal—namely, quartz—in which this effect of rotating the plane of polarization was first observed.

I take a clear plate of quartz, just 1 millimetre in thickness, and interpose it between the crossed Nicol prisms. You will note how the introduction of this plate of quartz brings *some* light into view.

Suppose we now turn the analyzer to try and obtain extinction: we get tinting. If we put in a coloured glass so as to work with one kind of light only, we shall get extinction at a particular angle. The table of data to which I invite your

Optical Torsion produced by Plate of Quartz.

	1 millimetre.	3·75 millimetres.
	°	°
Red	19	71·2
Orange	21·5	80·6
Yellow	24	90
Green	29	108·7
Peacock	31	116·2
Blue	35·5	133·1
Violet	42·8	161

attention states this amount for the different colours. If we use a piece of quartz so thick that it rotates any particular tint just 90°, that tint will be cut off by the crossed analyzer, and all others will—in greater or less proportion—be transmitted, so that the resulting tint will be complementary to that cut off. For example, a slice just so thick as to twist yellow waves round 90° must be 3·75 millimetres thick. (I may remark, for the benefit of those who think it easier to express this exact thickness in fractions of a British inch, that the quartz which rotates yellow light 90° must have a thickness equal to one-eighth, plus three-sixteenths of an eighth, plus one sixty-fourth of an eighth of an inch.) When such a quartz is placed between the crossed Nicols, the light shown is yellow; but if placed between parallel Nicols (*i.e.* in the bright field), it shows a rich purplish-violet colour, the complementary of the yellow. This particular tint Biot found to be excessively sensitive, the smallest inaccuracy in adjustment between the prisms at once producing a change, the colour appearing too red or too blue, according to the direction in which the analyzer has been turned out of exact adjustment. This tint is accordingly known as the "transition tint" or "sensitive tint," its accurate definition being due to the fact that the human eye is more sensitive to the presence or absence of the complementary yellow than to any other tint in the whole spectrum. If we take, however, a quartz plate twice as thick as this—namely, 7½ millimetres thick—this will give the yellow light a torsion of 180°. Hence this gives the purple transition tint in the dark field, and is yellow in the bright field. A quartz plate 11¼ millimetres thick gives again a transition tint in the bright field. I shall recur presently to the question of the transition tints of the several orders.

One of the familiar facts in this subject is that there are two kinds of quartz crystals, optically alike in every other respect, differing only in this, that one kind produces a right-handed twist, the other kind a left-handed twist. All the pieces of quartz I have so far employed are right-handed specimens. I now introduce two small slices of crystal, each 3¾ millimetres thick, giving the yellow tint when the Nicols are exactly crossed, but you will notice that when we are using the right-handed crystal, the tint grows reddish as the analyzer is turned towards the left, and greenish when the analyzer is turned towards the right; whereas, when I substitute the left-handed slice, the tint grows greenish as the analyzer is turned toward the left, and reddish when it is turned toward the right. If the analyzer is turned through an exact right-angle, we get an extinction of the yellow light, the remaining blue and red rays combining to give us the purple transition tint.

You will have noticed that the way in which we have (approximately) measured the angle of rotation has been first to set the analyzer to extinction, then to introduce the substance which has the property of rotating the beam, then to turn the analyzer again to extinction, and read off its angle. For, of course, the angle through which the analyzer is turned measures the angle through which the plane of polarization has been turned.

It is possible, however, to show in the lantern something like a more obvious rotation of the light by introducing between the Nicols a crystal star, built up of radial pieces of mica, twenty-four in number (Fig. 8). You see in the bright field a white cross with black sectors at 45°. Or, in the dark field we have a black cross with vertical and horizontal arms, the sectors next to those that are black seeming dusky. If now I put in a quartz plate between the star and the analyzer, you see the cross shift round, and it shows colours, because the blue rays are twisted round more than the green, the green than the yellow, the yellow than the red. Repeating the experiment with the 3·75 millimetre quartz which turns yellow waves round just 90°, we get this gorgeous radiation of colours, and our black cross is turned into a yellow one. With the 7·5 millimetre quartz, the black cross is replaced by one of "transition" tint.

The black crosses seen in certain sections of natural crystals, sphæroliths, sections of stalactites, crystallizations of salicine and of Epsom salts, may also be used instead of the 24-rayed star of mica. But best of all I find to be the beautiful black cross which is seen by polarized light in the prepared crystalline lens taken from the eye of a fish. You notice how, when the fish lens is projected and the quartz introduced, the cross turns round.

This is, however, a rough-and-ready way of displaying the rotation, and it is of vast practical importance that precise methods of measuring the angle of rotation should be available—of vast importance, because in several large industries this optical method is applied as a species of handy analysis. I have named a solution of sugar as being an "active" substance. In the industry of sugar-refining, as in that of brewing, the strength of sugar in the liquids is directly measured by measuring its optical effect. Consequently there has been developed a special instrument, the *polarimeter*, for this express purpose.

I have here examples of several practical forms of polarimeters; there are diagrams of several more upon the walls.

The problem of finding the best polarimeter naturally leads to the inquiry what special means are there for making the observation of the angle more precise than by merely observing the extinction of the light, its restoration when the active substance is interposed and the subsequent renewal of extinction when the analyzing prism is turned.

Biot considered that much greater accuracy could be attained by watching for the restoration of the sensitive tint than by

FIG. 8.—Mica disk of twenty-four rays, showing black cross in the dark field.

watching for the mere restoration of extinction of the light. Accordingly we will use the plate of quartz 7·5 millimetres thick, giving the purple tint, to enable us to measure the rotation produced by the tube of sugar solution which is now inserted in the beam of polarized light. You notice how the tint has changed. But I have only to turn the analyzer to an amount equal to that to which the light has been twisted by the sugar, and again I obtain the sensitive transition tint.

The eye is not always, however, alive to minute changes of colour in a single coloured patch; it much more readily distinguishes a minute difference between two tints when both are present at once. Hence Soleil devised the well-known biquartz arrangement, consisting of two pieces of crystal, equal in thickness but possessing opposite rotations. You will notice how the slightest inaccuracy in placing the analyzer causes the two halves of the field to differ in tint. This is especially marked when the tint chosen is the transition purple.

(*To be continued.*)

THE PLANET URANUS.

THAT anomalous section of the solar system, Uranus and its satellites, offers yet a wide field of investigation to astronomical specialists of all kinds. Its figure, its rotation, satellites, and physical constitution altogether, are moot points, which should be more or less settled with the increased optical power now at our disposal.

The circumstances attendant upon the discovery of Uranus in 1781 (Phil. Trans., 1781, p. 492) are matters of common knowledge. The planetary nature of the supposed comet seems to have been first suspected by Maskelyne, and it was this suggestion that induced Lexell to calculate for it a circular orbit in 1781 (Grant's "History of Physical Astronomy," p. 274). The elliptic elements of the planet were first calculated by Laplace in 1782 (*Mém. Acad. des Sciences*, Paris, January 1783).

The first measures of the Uranian diameter were singularly incongruous. Herschel found it in March 1781 to be 2″·53; whilst in the following month he measured it as 4″·52 and 5″·2, (Phil. Trans., 1781, p. 494). A like discordance occurred in the results obtained by other astronomers. Maskelyne fixed the magnitude of the apparent diameter as 3″, whilst Mayer, of

Manheim, estimated it to be as high as 10″ (Grant's "History of Astronomy," p. 275).

The difference between these measures of the diameter of Uranus would seem to be a consequence of the fact that it is always extremely difficult to get the planet clearly defined in the field of the telescope. Herschel himself noted (Phil. Trans., 1798, p. 69), "The Georgian planet is not so well defined as, from the extraordinary distinctness of my present 7-feet telescope, it ought to be. There is a suspicion of some apparatus about the planet."

Herschel several times had the impression that Uranus was surrounded with a ring. One of his observations is contained in the following (Philosophical Transactions, 1798, p. 68):—"My telescope is extremely distinct, and when I adjust it upon a very minute double star, which is not far from the planet, I see a very faint ray, like a ring crossing the planet, over the centre. This appearance is of an equal length on both sides, so that I strongly suspect it to be a ring. . . . I have turned the speculum one quadrant round, but the appearance of the very faint ray continues where it was before, so that the defect is not in the speculum nor is it in the eye-piece." Later observations, however, led Herschel to conclude "that Uranus has no ring in the least resembling that, or rather those, of Saturn."

Following upon the observations as to the existence of a ring round Uranus, are found others relating to its polar compression. The flattening at the poles was first observed by Herschel in February 1794 (Phil. Trans., 1798, p. 69), and announced in the following words: "The planet seems to be a little lengthened out, in the direction of the longer axis of the satellite's orbit;" and again in April of the same year: "The disk of the planet seems to be a little elliptical." Mädler measured the ellipticity in 1843, and found it 1/9·92 (Grant's "History of Astronomy," p. 278). Schiaparelli, in 1883, using two different methods, obtained the results 1/10·98 and 1/10·94 (*Astr. Nach.*, No. 2526). A few measures made by Young in the same year gave an ellipticity 1/14 ("General Astronomy," Young, p. 367). The fact that the ellipticity was in the same plane as the major axis of the satellite's orbit led Herschel to conclude from analogy with Jupiter and Saturn, "That the Georgian planet also has a rotation upon its axis of a considerable degree of velocity" (Phil. Trans., 1798, p. 71). Other observers of the bulging out of the Uranian equator—Schiaparelli, Young, Safarik—agree with Herschel in saying that the plane is coincident with that of the satellite's motion, but the following observations of markings on the surface of Uranus lead to an entirely different conclusion.

Buffham noticed some bright markings on Uranus in 1870–72 (*Monthly Notices*, vol. xxxiii. p. 164), and, from observations of their motion, deduced the time of rotation as twelve hours, but the plane of rotation was *not* coincident with that of the satellite's orbit. This was borne out by observations of dusky bands by Young, in 1883 ("Princetown Observations," 1883); of apparent equatorial belts by the brothers Henry, in 1884 (*Comptes rendus*, t. xcviii. p. 1419); and observations in 1884, at Nice, of a bright spot by Lockyer, Perrotin, and Thollon (*Comptes rendus*, t. xcviii. pp. 717, 967). The plane of rotation, according to these observers, is from 15° to 40° from the trend of the satellite's. Thus the difference between the two sets of observations amounts to nearly half a right angle. Does the error lie in the observation of the belts, or in the measurements of the planet's ellipticity and the satellite's orbit? This is an enigma which yet remains to be solved, and another character of Uranus requiring investigation.

Herschel made the first determination of the mass of Uranus in 1788 (Philosophical Transactions, 1788, p. 369), and found it to be 17·740612 as compared with the earth, or about 1/18,000 that of the sun. Bouvard found a value 1/17,918; Lamont, in 1837, 1/24,605. Lassell's observations of the motion of the satellites gave a value 1/20,897, whilst Struve's observations gave a value 1/26,860. The mass, 1/22,600, found by Newcomb ("Washington Observations," 1873), is probably the most correct, and he estimates that the probable error in the denominator is not more than 100. This mass, revolving round the sun at a mean distance of about 1800 millions of miles, must exert considerable influence upon bodies near it, influence which may often predominate over that of the sun.

But it is the question of Uranian satellites that is so enigmatical. Herschel discovered two on January 11, 1787 (Phil. Trans., 1787, p. 125 *et seq.*), and in 1798 announced the discovery of four more. Regarding the real existence of these four, Herschel remarks (Phil. Trans., 1798, p. 66): "It remains now only to be mentioned that, in such delicate observations as these of the additional satellites, there may possibly arise some doubts with those who are very scrupulous; but as I have been much in the habit of seeing very small and dim objects, *I have not been detained from publishing these observations sooner, on account of the least uncertainty about the existence of these satellites*, but merely because I was in hopes of being able soon to give a better account of them, with regard to their periodical revolutions."

Sir John Herschel observed the two brightest satellites between 1828 and 1832 (Mem. Ast. Soc., vol. viii. p. 1); but "of other satellites," he says, than these, "I have no evidence," although the telescope he was using was precisely similar to that used by his father. A systematic search was made by Lassell for the lost satellites, and a definite announcement of the discovery of two satellites between Uranus and the two brightest was made in 1851 (*Monthly Notices R.A.S.*, xi. 248). He declares, however, that it would have been impossible for Sir William Herschel to have seen these two faint bodies; and although Prof. Holden has attempted to identify the two with two of Herschel's quartett, the balance of evidence is certainly to the contrary, and we are bound to conclude that no one has ever seen the four but Herschel himself.

Herschel announced, in 1798 (Phil. Trans., 1798, p. 48), the retrograde movements of the Uranian satellites in the terse paragraph, "I take this opportunity of announcing that the movement of the Georgian satellites is retrograde." The fact that their orbits were inclined about 80° to the ecliptic plane was discovered in 1788.

Herschel also particularly noticed that the light of the two brightest satellites was subject to considerable fluctuations, and in 1815 (Phil. Trans., 1815, p. 356) he suggests for a cause that given by Newton in the "Principia" to account for the periodical variability of certain stars. His conclusion was:—"The variable brightness of the satellites may be owing to a rotation upon their axes, whereby they alternately present different parts of their surface to our view. These variations may also arise from their having atmospheres that occasionally hide or expose the dark surface of their bodies, as is the case with the sun, Jupiter, and Saturn."

The two inner satellites, Ariel and Umbriel, discovered by Lassell, seem also to fluctuate in brightness, and Newcomb observed in 1875 ("Washington Observations," 1873, p. 43):—"I strongly suspect that Ariel, at least, belongs to that class of satellites of which the brilliancy is variable and dependent on its position in its orbit. The evidence of variability of some kind seems indisputable, as I have repeatedly failed to see it when the circumstances, distance from the planet included, were in every respect favourable, and when Umbriel, though less favourably situated, was visible. On the other hand, there were two occasions, January 28, 1874, and March 25, 1875, when it was surprisingly conspicuous. Unfortunately no systematic record was made of the times when, being near greatest elongation, it was looked for and not seen; but on at least one such occasion its position angle was 180°. An inspection of the observations shows that out of the eight observations only two were made near the southern elongation; while in the two cases where its brightness was most remarkable, the position angles were respectively 348° and 351°."

The time of revolution of Ariel is 2·520378 days at a mean distance of 120,000 miles; its diameter is about 500 miles.

Herschel also observed that these satellites became invisible some distance from the planet's disk (Phil. Trans., 1798, p. 75); thus, on February 22, 1791, the first satellite was lost when 22″ from the planet. This distance was not, however, constant, for on May 2, 1791, the same satellite disappeared at an apparent distance 19″·8. A table is given showing at what distance from the planet the first and second satellites respectively became invisible during a period of seven years. A fact exhibited by this table is that the distance at which the satellites disappeared regularly diminished from 1791 to 1797, until in the latter year the first satellite was traced to 4″·8 from the planet's disk. The reason assigned to account for this phenomenon by Herschel was that the light of the satellites was "put out" by the stronger light of their primary, and regarding this he remarks (Phil. Trans., 1798, p. 78):—"We may avail ourselves of the observations that relate to the distances at which the satellites vanish, to determine their relative brightness. The second satellite generally appears brighter than the first; but as the former is usually lost farther from the planet than the latter we may admit the first satellite to be rather brighter than the second." The diameters of the first and second satellites are about 1000 and 800 miles respectively, hence Herschel's comparative measures were correct. R. A. GREGORY.

BABYLONIAN ASTRONOMY.[1]

I.

CLASSICAL writers seem to be unanimous in considering the Babylonians as the most ancient astronomers; a close examination shows, however, that the statement emanated from one or two writers, and that all the others merely repeated it without taking the trouble of verifying it. The figures given by various authors as to the period covered by the Babylonian astronomical observations are most extravagant, but the disagreement of the authors proves their inaccuracy. In spite of all discrepancies, one fact comes out clearly—that is, the Semitic origin of the Babylonian astronomy. Belus, the eponymic king of Babylon, considered by the classics as the first ruler or even the colonizer of Babylonia, is called the "inventor of astronomy," and Seneca considered the work of Berosus as a translation of that of Belus.

If we turn now to the native documents—the tablets now in the British Museum—we can class them under two distinct periods, those previous to the Greek rule and those contemporaneous with the Seleucids. Some tablets of the first period give us lists of certain astronomical or atmospheric observations, with the events which took place at the same time; the others are mere reports of the official astronomers stating what they observed, as the occurrence or non-occurrence of an eclipse. A characteristic point is that the observations are in no case dated: the day and the month are, indeed, given, but not the year; and this leaves no doubt as to the real character of these documents.

The Babylonians held the belief that the sky was a reflection of what was going on upon the earth: if, therefore, a certain event took place at the time of the conjunction of two stars, the same event would repeat itself when the same conjunction would take place. There were no predictions, but merely statements of real facts taking place at the same time in the sky and upon the earth, the actual date of which was of no consequence, as the object in view was to establish the supposed connection between what happened in the sky and what happened upon the earth—in short, correlative events. It appears also that the Babylonians admitted the existence of a cosmical year—that is, a period after which the same events were to occur again; this period was one of 360,000 years. The number was obtained by a mere play on figures. The basal number of the Semites was six, as the system used to form their numerals shows; by multiplying it by ten (the number of the fingers) they formed the *soss*, 60; by multiplying again by ten was formed the *ner*, 600; and the square of the former gave 3600, the *sar*, or "multitude." The cosmical year was supposed to be formed of 100 *sari*, or the square of the *ner*; this was probably the number given by Berosus to the antediluvian period, 10 *sari* being attributed to each king. From this number were derived those given by the classics as the period of the Babylonian astronomical observations—720,000 years (or two cosmical years) by Epigenes, 1,440,000 (or four cosmical years) by Simplicius; the 490,000 years given by Berosus, according to Pliny, represent one cosmical year and 130,000 years, elapsed in his opinion, of the actual period. It cannot be doubted, however, that the stars have been observed in Babylonia from a very high antiquity, for we have lists of eclipses for almost every day in the year, and as these eclipses actually took place, they prove a long period of observations; some of the astronomical statements also refer to the pre-Akkadian period—that is, earlier than 7000 B.C. If the Babylonians, in spite of this long period of observations, never arrived at any correct knowledge of the motion of the planets and stars, it is no doubt due to their deficient calendar.

Omen-taking being therefore the only object of the Babylonian astronomers, or rather star-gazers, they distributed the stars and planets under the direction of certain gods, according to the influence attributed to them. This has unfortunately thrown much confusion into their nomenclature, for the name of the god is sometimes taken for that of the star which he is supposed to influence, and the same god influences several; in some cases, also, the same star is sometimes under the influence of one god, sometimes under that of another. Besides this, we have many groups of seven stars: the seven *dibbu* or planets, the seven *masu* or double stars, the seven *zikru* or males, &c. The stars were also divided by regions—the twelve stars of the north, and the twelve stars of the south—and associated in groups of two with certain months; the months themselves were associated with certain regions, and were under the guidance of a god.

In all this we see the rudiments or rather germs of astrology; but, as astrology requires a knowledge of the movements of the planets, the Babylonians never arrived at this point—they merely took omens, and to do so they appear to have proceeded exactly as did the augurs of Rome. They described first in the sky a circle with their rod, divided this circle into eight divisions by lines passing through the centre, and then observed the position of the stars in this imaginary geometrical figure, and what kind of phenomena took place, in order to draw from them their omens. Having made his observation, the operator, or priest, then referred to the lists of omens, copies of which have come to us, to ascertain if the same celestial phenomenon had already been noted, expecting as correlative fact the same terrestrial event which had happened in the previous case.

It may be noticed, before concluding, that all the astronomical omen tablets recovered from Nineveh or Babylon are written in the Semitic language; there are no doubt a great many ideograms, but the phonetic complements, the words spelt phonetically, and the grammatical peculiarities show that the idiom used must be Semitic.

[1] Abstract of the first lecture delivered by Mr. G. Bertin at the British Museum.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DUBLIN.—At the Summer Commencements of the University of Dublin, held in Trinity College, Dublin, on June 27, Mr. F. W. Burbidge, Curator of the Trinity College Botanical Gardens, received the honorary degree of M.A. The Public Orator, Prof. Palmer, called attention to the benefits conferred on botanical science by Mr. Burbidge, by his travels in Borneo, and by his labours in elucidating the natural history of those classic flowers the Narcissi and the Hellebores. The honorary degree of LL.D. was conferred on Mr. Valentine Ball, F.R.S., the Director of the Science and Art Museum, Dublin, and at one time Professor of Geology and Mineralogy in Trinity College, Dublin, whose works on the geology and mineralogy of India, and researches on the identification of the animals and plants of India which were known to the early Greek authors, merited the eulogium pronounced on them by the Orator.

SOCIETIES AND ACADEMIES.

LONDON.

Linnean Society, June 6.—Mr. Carruthers, F.R.S., President, in the chair.—Dr. John Anderson, Mr. J. G. Baker, Dr. Braithwaite, and Mr. F. Crisp, were nominated Vice-Presidents.—Prof. Martin Duncan exhibited under the microscope some beautifully mounted preparations of the ambulacral tentacles of *Cidaris papillata*, and drew attention to the fact, previously unrecorded, that the tentacles of the abactinal region of the test differ in form and character from those of the actinal region. The latter have a well-developed terminal disk, and are richly spiculated; whereas the former have no disk, but terminate distally in a pointed extremity with very few spiculæ. Mr. W. P. Sladen made some remarks on the significance of this dimorphism with reference to its archaic character, and its relation to the primitive forms of Echinoids and Asteroids.—Mr. Narracott exhibited a singular fasciated growth of *Ranunculus acris*, found at Castlebar Hill, Ealing.—Mr. H. B. Hewetson exhibited under the microscope a parasite of Pallas's Sand Grouse (*Syrrhaptes paradoxus*) taken from a bird shot in Yorkshire, and described as a species of *Argas*. Mr. Harting pointed out that an apparently different parasite from the same species of bird had been recently described by Mr. Pickard Cambridge (*Ann. Mag. Nat. Hist.*, May 1889) under the name *Hæmaphysalis peregrinus*.—Dr. Cogswell showed some examples of Jerusalem Artichoke and Potato, to illustrate the spiral development of the shoots from right to left.—Governor Moloney, of the colony of Lagos, exhibited a large collection of birds and insects from the Gambia, the result of twelve months' collecting in 1884-85. The birds, belonging to 134 species, had been examined and named by Captain Shelley. Amongst the beetles, of which 89 species had been collected, he called attention specially to *Galerita africana* and *Tefflus megelii*, and to the Rhinoceros and Stag-horned Beetles. Of butterflies there were 90 species, amongst which the most noticeable and characteristic were the *Acreas* and the pale-green *Eronia thalassina*, said to be typically Gambian. The moths, of which some 220 species had been brought home, were named by Mr. Herbert Druce, and several had proved to be new or undescribed. A portion of this collection had been exhibited at the Indian and Colonial Exhibition of 1886, but had since been carefully gone over and named, and was now exhibited for the first time in its entirety.—Mr. Herbert Druce alluded to some of the Lepidoptera which are most characteristic of the Gambia region; and Mr. Harting made some remarks upon the birds, pointing out the wide geographical range of some of the species which had been collected.—Mr. Clement Reid exhibited several specimens of fossil plants from a newly-discovered Pleistocene deposit at South Cross, South-elmham, near Harleston.—Mr. D. Morris exhibited specimens of the fruit of *Sideroxylon dulcificum*, the so-called "miraculous berry" of West Africa, belonging to the *Sapotaceæ*. Covered externally with a soft sweet pulp, it imparts to the palate a sensation which renders it possible to partake of sour substances, and even of tartaric acid, lime-juice, and vinegar, and to give them a flavour of absolute sweetness. The fruit of *Thaumatococcus* (*Phrynium Danielli*), possessing similar properties, was also shown; and living plants of both had lately been received at Kew from Lagos through Governor Moloney.—Mr. Thomas Christy exhibited growing plants of *Antiaris toxicaria* (the Upas-tree) and *Strophanthus Kombe*, both of them poisonous, to show the similarity of the foliage.—On behalf of Dr. Buchanan White, a paper was then read by Mr. B. D. Jackson, entitled a "Revision of the British Willows."

Royal Meteorological Society, June 19.—Dr. W. Marcet F.R.S., President, in the chair.—Mr. W. Marriott gave a very graphic and interesting account of the recent thunderstorms which have prevailed over this country. On Sunday, June 2, a thunderstorm passed across the country in a northerly direction from Wiltshire about 5 a.m., and reached Edinburgh by 10.44. It travelled at the rate of about 50 miles an hour. It is possible that this storm travelled still further north, and reached Kirkwall at 3.37 p.m. A severe thunderstorm prevailed over the neighbourhood of the Tweed between 11 a.m. and noon, and was accompanied by hail of very large size, some of the stones being 5 inches in circumference. A very destructive storm occurred over the whole of the north-west of England and south of Scotland during the afternoon; much damage was caused by lightning, and very large hail fell over an extensive area. Some of the hailstones measured 7 inches in circumference and weighed 7 ounces. During the night of the same day a severe thunderstorm prevailed over Norfolk, which was also accompanied by very large hailstones, some of which were 5 to 6 inches in circumference. On Thursday, the 6th, thunderstorms prevailed during the afternoon over the whole of the south-east of England; that which passed over the Metropolis about 9 o'clock was remarkable for the brilliant and continuous display of lightning. During the same night and in the early morning of the following day a very destructive storm prevailed over the Eastern Counties, much damage being done by the lightning in the north-west of Norfolk. Severe hailstorms occurred between 2 and 3 a.m., both at Margate and Ipswich. During the afternoon of the 7th, destructive thunderstorms prevailed over the whole of the Southern Counties, much damage being done by lightning, while at Tunbridge Wells there was a most remarkable hailstorm. One of the hailstones which was weighed was actually half a pound in weight. An interesting collection of over forty photographs of lightning taken during the storm on June 6 was also exhibited to the meeting. In addition to the sinuous, ribbon, and meandering flashes of lightning, several photographs showed knotted, multiple, and dark flashes.—The following papers were also read:—The climate of British North Borneo, by Mr. R. H. Scott, F.R.S.—On the variation of the temperature of the air in England during the period 1849 to 1888, by Mr. W. Ellis.—Atlantic weather and rapid steamship navigation, by Mr. C. Harding.—Meteorological phenomena observed during 1875-87 in the neighbourhood of Chelmsford, by Mr. Henry Corder.—Rainfall in China, and meteorological observations made at Ichang and South Cape in 1888, by Dr. W. Doberck.

Geological Society, June 5.—Prof. J. W. Judd, F.R.S., Vice-President, in the chair.—The following communications were read:—Observations on some undescribed lacustrine deposits at Saint Cross, Southelmham, in Suffolk, by Charles Candler (communicated by Clement Reid). Some remarks were made on this paper by Mr. Clement Reid, Prof. Prestwich, and Mr. Lydekker.—On certain Chelonian remains from the Wealden and Purbeck, by R. Lydekker. In the first part of the paper the author described a portion of the hind lobe of a Chelonian plastron from the Wealden, which was remarkable as showing a median row of epidermal shields. The name of *Archæochelys valdensis* was proposed for the form so represented. The new generic term *Hylæochelys* was also proposed for the Purbeck Chelonian described by Sir R. Owen as *Pleurosternum latiscutatum*, and was also taken to include some other forms from the Wealden. The second section of the paper treated of the affinities of *Pleurosternum*. It was concluded that *Digerrhum*, Cope (as represented by the so-called *Platemys Bullocki*), is identical with *Pleurosternum*, of which there appears to be only one Purbeck species. Evidence was brought forward to show that in the adult of *Pleurosternum* the pubis had a facet for articulation with the xiphiplastral; and it was proposed to refer this genus, together with *Platychelys* and *Baëna*, to a new section termed "Amphichelydia," which was regarded as allied both to the true Cryptodira and to the Pleurodira.—On the relation of the Westleton Beds or Pebbly Sands of Suffolk to those of Norfolk, and on their extension inland; with some observations on the period of the final elevation and denudation of the Weald and of the Thames Valley, by Prof. Joseph Prestwich, F.R.S. The author in this, the first part of his paper, described the Westleton beds of the East Anglian coast. He commenced with a review of the work of previous writers, especially Messrs. Wood and Harmer, and the members of H.M. Geological Survey, including Messrs. H. B. Woodward, Whitaker, and Clement Reid. In discussing this work, particular attention was paid to the Bure Valley beds, which were considered as a local fossiliferous condition of the Pebbly Sands; but the term is not so applicable to these sands as that of the "Westleton and Mundesley Beds," which the author proposed in 1881. The Westleton beds were carefully described, as seen in coast-sections in East Anglia, proceeding from south to north, and the following classification was adopted:—

The Westleton and Mundesley series (The Mundesley section of it).	1. Laminated clays, sand, and shingle with plant-remains and freshwater shells (the Arctic forest-bed of Reid). 2. Sand and quartzose shingle with marine shells (the *Leda myalis* bed of King and Reid). 3. Carbonaceous clay and sands with flint-gravel, and pebbles of clay, driftwood, land and lacustrine shells and seeds (the Upper freshwater bed of Reid).
The Forest-bed series of Reid (exclusive of No. 3 of above).	4. A greenish clay, sandy and laminated in places, containing abundant mammalian remains, and driftwood, with stumps of trees standing on its surface (the forest- and elephant-bed of authors; the estuarine division, in part, of Reid). 5. Ferruginous clay, peat, and freshwater remains and gravel (the Lower freshwater bed of Reid).

The Westleton beds were found to rest with discordance on various underlying beds; in places on the Forest series, elsewhere on the Chillesford Clay, whilst occasionally the latter had been partly or entirely eroded before the deposition of the Westleton beds. In the north, where the present series dies out, they come in contact with the so-called Weybourn Crag, which the author supposed to be the equivalent of the Norwich Crag. A similar discordance has been noted between the Westleton beds and the overlying glacial beds, so that the former mark a distinct period, characterized by a definite fauna, and by particular physical conditions. The Westleton beds being marine, and the Mundesley beds estuarine and freshwater, the author proposed to use the double term to indicate the two facies, as has been done in the case of other deposits. But these facies were found to be local, and the most persistent feature of the beds is the presence of a shingle of precisely the same character over a very wide area. By means of this the Westleton beds can be identified far beyond East Anglia, and where there is no fossil evidence, and they throw a considerable light on important physiographical changes. The author described the composition of the shingle, which, unlike the glacial deposits, contained pebbles of southern origin. The paper concluded with a list of fossils, excluding those of the Forest-bed (the stumps of which, the author considered, were frequently in the position of growth). Should the Forest-bed eventually prove to be newer than the Chillesford beds, it was maintained that the former must be included in the Westleton series, and its flora and fauna added to the list, whilst if, on the contrary, the Forest-bed should be proved synchronous with the Chillesford beds it must be relegated to the Crag. The second part of this paper will treat of the extension of these beds into and beyond the Thames Valley, and on some points connected with the physical history of the Weald. The reading of this paper was followed by a discussion, in which Mr. B. H. Woodward, Mr. J. A. Brown, and Mr. Topley took part.

June 19.—Prof. J. W. Judd, F.R.S., Vice-President, in the chair.—The following communications were read:—On tachylyte from Victoria Park, Whiteinch, near Glasgow, by Frank Rutley.—The descent of *Sonninia* and of *Hammatoceras*, by S. S. Buckman.—Notes on the Bagshot Beds and their stratigraphy, by H. G. Lyons.—Description of some new species of Carboniferous Gasteropoda, by Miss Jane Donald; communicated by J. G. Goodchild.—*Cystechinus crassus*, a new species from the Radiolarian marls of Barbados, and the evidence it affords as to the age and origin of those deposits, by J. W. Gregory.—The next meeting of the Society will be held on Wednesday, November 6.

Zoological Society, June 18.—Prof. Flower, F.R.S., President, in the chair.—The Secretary exhibited (on behalf of Mr. J. F. Green) a very fine example of the Common Eel, obtained from a pond in Kent, and measuring upwards of 4 feet in length.—Mr. B. B. Woodward exhibited, and made remarks on, a drawing representing a living example of *Ærope kaffra*, a carnivorous snail from the Cape Colony.—Mr. Woodward also exhibited an example of a fossil shell from the Eocene of the Paris Basin (*Neritina schmideliana*), and a section of it showing the peculiar mode of its growth.—Mr. Eadweard Muybridge, of the University, Pennsylvania, exhibited a series of projections by the oxyhydrogen light, illustrative of the consecutive phases of movements by various quadrupeds while walking, trotting, galloping, &c., and of birds while flying.—A communication was read from Prof. Henry H. Giglioli, containing the description of a supposed new genus and species of Pelagic Gadoids from the Mediterranean, proposed to be called *Eretmophorus kleinenbergi*.—Lieut.-Colonel H. H. Godwin-Austen, F.R.S., read the first of a proposed series of papers descriptive of the land-shells collected in Borneo by Mr. A. Everett, with the descriptions of new species. The present paper treated of the *Cyclostomaceæ*.—Captain G. E. Shelley read a list of birds collected by Mr. H. G. V. Hunter in Masai Land during the months of June, July, and August 1888. The collection (which Mr. Hunter had presented to the British Museum) consisted of examples of ninety-four species, seven of which were described by the author as new to science.—Mr. P. L. Sclater, F.R.S., gave a further description of Hunter's Antelope (*Damalis hunteri*) from specimens obtained by Mr. H. C. V. Hunter on the River Tana, Eastern Africa.—Mr. F. E. Beddard read a paper on the fresh-water and terrestrial Annelids of New Zealand, with preliminary descriptions of new species.—A communication was read from Mr. H. W. Bates, F.R.S., containing descriptions of some new genera and species of Coleopterous insects collected by Mr. Whitehead during his recent visit to Kina Balu. The collection was stated to comprise an unusual proportion of new and remarkable forms.—This meeting closed the session. The next session (1889–90) will begin in November 1889.

Victoria Institute, July 1.—Annual Meeting.—Sir George Stokes, Bart., P.R.S., President, in the chair.—After the reading and adoption of the Report, an address by Prof. Sayce was read by Dr. Wright. It gave a description of what has become known as to the conquests of Amenophis III., the palace and its archives, which have only lately been discovered, and which Prof. Sayce went last winter to investigate on the spot. Of the tablets and inscriptions, he said:—"From them we learn that in the fifteenth century before our era—a century before the Exodus—active literary intercourse was going on throughout the civilized world of Western Asia, between Babylon and Egypt and the smaller States of Palestine, of Syria, of Mesopotamia, and even of Eastern Kappadokia. And this intercourse was carried on by means of the Babylonian language, and the complicated Babylonian script. This implies that, all over the civilized East, there were libraries and schools where the Babylonian language and literature were taught and learned. Babylonian, in fact, was as much the language of diplomacy and cultivated society as French has been in modern times, with the difference that, whereas it does not take long to learn to read French, the cuneiform syllabary required years of hard labour and attention before it could be acquired." A vote of thanks was passed to Prof. Sayce for his address, to Dr. Wright for reading it, and to the President.

Paris.

Academy of Sciences, June 24.—M. Des Cloizeaux, President, in the chair.—On the condition of matter near the critical point, by MM. L. Cailletet and E. Colardeau. The series of experiments here described, and carried out for the purpose of testing the views of Cagniard de Latour, Andrews, Ramsay, and other physicists, tend to show that the critical temperature of a liquefied gas is not that at which the fluid is totally evaporated abruptly within the space containing it, for the liquid state persists beyond this temperature; nor is it the temperature at which a fluid and its saturated vapour have the same density; but it is the temperature at which a fluid and the gaseous atmosphere above it become capable of being mutually dissolved in any proportion, so as to form, when shaken, a homogeneous mixture. This interpretation of the critical point supplies some interesting data on the unbroken continuity of the liquid and gaseous states of matter.—On the heat of formation of the hyponitrites, by M. Berthelot. M. Maquenne's experiments on the hyponitrites, here communicated to the Academy by M. Berthelot, seem to decide the question of the formula of hyponitrous acid, which corresponds with the percentage composition suggested by Divers, but with twice the molecular weight. The complete analysis of the salts of calcium and strontium removes all further doubt on this point.—Restoration of the skeleton of Dinoceras, by M. Albert Gaudry. The specimen here described is that of Marsh's *D. mirabile*, copies of which have been supplied both to the British Museum and to the new gallery of palæontology in the Paris Museum.—On the mastodons found at Tournan, Gers, by M. Albert Gaudry. The numerous remains of mastodons recently found by M. Marty in the Middle Miocene of Tournan, all belong to *M. angustidens*. Amongst them is the most perfect head of any mastodon yet brought to light in Europe. This, with some other important parts, has been secured for the Paris Museum, and affords facilities for determining the specific differences between *M. angustidens* of the Miocene and the *M. americanus* of the Quaternary epoch.—On the occlusion of gases in the electrolysis of the sulphate of copper, by M. A. Soret. Having already shown (*Comptes rendus*, November 5, 1888) that certain relations exist between the quantities of gas occluded in electrolytic copper and the conditions of temperature and acidity of the electrolyte, the author has carried out some further experiments leading to more accurate results, and throwing some light on the action of the electrolysis in this particular case. He finds that the electrolytic copper contains carbon dioxide and hydrogen, the latter of which is in most cases present in largest proportion (five-sixths may be taken as an average), and in all cases when the electrolyte is acid; further, that the brittleness of the deposit of copper is related to the presence of carbon dioxide.—On the compounds of ruthenium and ammonia, by M. A. Joly. The author has already shown that the constitution of the red chlorides of ruthenium was more complex than was supposed by Claus. It results from his further researches that the chloride and all bodies derived from it contain an atom of nitrogen more than was indicated by Claus, and that their formula might be written thus: $Ru . NO . OH . X_2(4NH_3)$.—On the presence of sulphate of soda in the atmosphere, and on the origin of saline dust, by M. P. Marguerite-Delacharlonny. Some facts are here adduced which may give a more general and perhaps a more correct explanation of the presence of the sulphate of soda in the atmosphere than that of M. Parmentier.—Camphor and borneol of rosemary, by M. A. Haller. A new method is described for separating these substances.—Mean altitude of the continents and mean depth of the oceans, by M. A. de Tillo. From the author's minute researches it results that the numerical data hitherto accepted by various authorities require to be modified. He finds the mean elevation of all the continents above sea-level to be 693 metres: northern hemisphere, 713; southern hemisphere, 634; Europe, 317; Asia, 957; Africa, 612; North America, 622; South America, 617; Australia, 240. Mean depths of all the oceans, 3803: Pacific, 4380; Atlantic, 4022; Indian, 3674; northern seas, 3627; southern seas, 3927.

BERLIN.

Physical Society, June 7.—Prof. von Helmholtz, President, in the chair.—Dr. R. von Helmholtz communicated the results of his experiments on the radiating power of flames. The problem which he had set before himself was to determine the relationship between the radiant energy of flames, and the amount of gas consumed for their production. The latter was measured by the fall of the gasometer-globe which contained the gas, the former by means of a bolometer, for each of whose scale-divisions the equivalent value in heat-units had been carefully determined by three different methods. The radiating energy of the flames depended upon a number of conditions which were each severally investigated; as, for instance, the size and shape of the flames, the amount of foreign gases introduced, and the ratio of the amount of oxygen to the amount of gases with which it was mixed. For the purposes of comparative measurements, a moderately high flame was chosen, which produced no smoke and was 6 mm. thick. Luminous flames radiated more energy than non-luminous, and it was proved by an extended series of careful quantitative experiments that the radiating power of the flames was not dependent upon their temperature. From this it follows that Kirchoff's law does not hold good for flames—a result which is, however, quite in accordance with the limitations he put to his law for those cases in which heat is directly converted into radiating energy. In the case of flames it must be borne in mind that chemical affinity comes additionally into play: the speaker entered fully into the influence of this upon the radiation of energy, and endeavoured to make it clear by means of an extremely interesting hypothesis. After this he stated the numerical data which he had obtained for both luminous and non-luminous flames, produced with a series of gases—hydrogen, carbonic oxide, methane, coal-gas, methyl-alcohol, &c. Starting as a basis with Julius's statement that the products of combustion are the only criteria of the amount of radiation, and hence calculating the radiating energy of the flames, he obtained values which corresponded very closely in most cases with those actually observed. Finally he calculated the total useful effect which can be obtained as radiant energy from the gases which are being consumed in the production of the flame. From this he arrived at the interesting result that it is far more economical to use the gases for driving a dynamo which supplies incandescent lamps, and to utilize the energy radiated from the latter, than to burn the gases, and utilize the energy which is radiated out from their non-luminous flames. The communication, as a whole, of which only a short sketch has here been given, contained a large number of very valuable quantitative results. —Dr. Budde spoke on "tautological" contacts in mechanics, and deduced the general conditions under which a close determination of contacts between surfaces and points is unnecessary ("tautological").

Physiological Society, June 14.—Prof. Munk, President, in the chair.—Dr. Openchowski spoke on the researches which he has carried on since 1883 on the movement and innervation of the stomach. The movements were recorded by introducing into the stomach a small bag filled with water and connected with a manometer, the motion of the column of fluid in the latter being recorded graphically. The fundus and first third of the stomach never exhibit any spontaneous peristaltic movements, these being confined to the second and last third, including the pylorus. The centre for the initiation of the motor movements lies in the ganglion cells under the serous coat which extend all over the stomach along the branches of the vagus nerve. The motor and inhibitory centres on which the movements of the cardiac end depend are situated in the brain and spinal cord; the motor centres lie in the corpora quadrigemina and in the spinal cord between the fifth and eighth thoracic vertebræ; the inhibitory centres lie in the corpus striatum, and a few are scattered in the spinal cord. The connection between the cranial centres and the stomach is provided by the vagi; there is no connection between the cranial and spinal centres. The centres for the pyloric end are situated in the same places as those for the cardiac end, but the centres which are inhibitory for the latter are motor for the former, and *vice versâ*. The speaker has studied the act of vomiting very fully. The stomach plays an active part in this act. After paralysis of the stomach, the movements of vomiting may be brought about, but do not lead to an ejection of the stomach's contents. After administering an emetic, such as sulphate of copper, the fundus and first third of the stomach is actively dilated; the pylorus is at the same time relaxed, and the contents of the small intestine are driven into the stomach by the contraction of the intestinal walls, and then, by the strong and progressive contractions of the last two-thirds of the stomach, they are driven on into the first third of the stomach. At this stage the stomach has a pear-like shape, the fundus being unduly distended. The reflex movements of vomiting now occur, and the pressure exerted by the abdominal muscles leads to the emptying of the highly distended fundus. As after paralysis of the stomach, so also after section of the vagi and excision of the stomach and intestines, the movements of vomiting occur when an emetic is administered. No *single* centre for vomiting appears to exist and be actively functional during the act, but there would seem rather to be a combination of co-ordinated centres, whose position has still to be more definitely ascertained.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

U.S. Commission of Fish and Fisheries, 4 vols.: G. Brown Goode.—Inorganic Chemistry: Ira Remsen (Macmillan).—Eclipses and Transits in Future Years: S. J. Johnson (Parker).—Fundamental Problems: Paul Carus (Open Court Publishing Company).—Rendiconti del Circulo Matematico (Palermo).—Avifauna Italica, parte prima: E. H. Giglioli (Monnier, Florence).—Injurious Farm and Fruit Insects of South Africa: E. A. Ormerod (Simpkin).—Gaseous Fuel: B. H. Thwaite (Whittaker).—Electricity: A. Rust (Spon).—American Resorts: B. W. James (Davis).—The Prospector's Hand-book, 4th edition: J. W. Anderson (Lockwood).—*Phormium tenax* as a Fibrous Plant, 2nd edition: edited by Sir J. Hector (Wellington, New Zealand).—Geology in Systematic Notes and Tables, 2nd edition: W. F. Gwinnell (Allman).—Kant's Critical Philosophy, vol ii. The Prolegomena; translated: J. P. Mahaffy and J. H. Bernard (Macmillan).—Physics of the Earth's Crust, 2nd edition: Rev. O. Fisher (Macmillan).—Schriften der Naturforschenden Gesellschaft in Danzig; Neue Folge, Siebenten Bandes, Zweites Heft (Danzig).—Observations made at the Blue Hill Meteorological Observatory, Mass., U.S.A., 1887: A. L. Rotch (Camb., Mass.).—Transactions and Proceedings of the New Zealand Institute, vol. xxi. (Trübner).

CONTENTS.

THURSDAY, JULY 11, 1889.

AFRICAN RIVER LIFE.

A Visit to Stanley's Rear Guard at Major Barttelot's Camp on the Aruhwimi; with an Account of River Life on the Congo. By J. R. Werner. (Edinburgh and London: Blackwood and Sons, 1889.)

THAT, with our present knowledge of its geography and resources, Africa should be considered *the* special field for travellers *en grand*, is not surprising. Nor is it strange that merchants and moneyed men should be attracted to a land so rich in the means and materials of commerce. Immense progress has of late years been made in filling up the blanks for which its maps were notorious up to a very recent generation of school-boys; but the impulse in this direction is not yet expended, and Europe awaits eagerly much-needed enlightenment on the Sahara and Western Soudan, besides those countries of which more is heard, and remains to be heard, in the development of our existing foreign or colonial relations. To the north, Algiers and Egypt; to the south, the Cape of Good Hope and neighbouring territories; and east and west, the coast lines, and outlying islands generally, of the main land, have long since become familiar localities to students of travel and current events. It is only, however, within the last ten or fifteen years that equatorial Africa has been fairly opened out. Across the huge continent Europeans have now placed a broad and continuous girdle, reaching from the mouth of the Congo at Banana to the dominions of the Sultan of Zanzibar. Looked at from west to east, the component parts of this girdle are the French Congo, won to France by M. De Brazza and Belgian concession; the Portuguese Congo, allowed to Portugal in deference to a long-asserted claim, the frequent rejection of which by the English Foreign Office seemed to demand a change of treatment; the Free State of the Congo, founded and acquired by Stanley and a host of explorers and emissaries serving the King of the Belgians, first among promoters of Central African exploration; the wide-spreading German lands obtained from the chiefs of Usagara, Nguru, Useguha, and Ukanio, by three skilful and enterprising negotiators, whose work—like that of the Society of German Colonization—was almost immediately taken under the protection of the Imperial ægis on the signatures being affixed to the Treaty of Berlin; and now the girdle has become deepened by the important addition of the tracts ceded to the chartered Imperial British East African Company. What may be done by the Company dealing with the African Lakes is a problem the solution of which should belong to the combined or separate action of both philanthropists and commercial speculators.

If the progress of mapping out Africa has been marvellously rapid in the second half of the present century, the educational gain to the civilized world from the process is due not only to the labours of practical exploration, but also to the literary skill and ability with which those labours have been recorded. Travellers such as Burton, Speke, Grant, Livingstone, Baker, Johnson, Thomson, and Stanley, have been enabled, by the possession of natural qualifications, to give to the world their personal impressions and experiences with more or less of artistic power, and the advantage to a reading and appreciative public has been consequently great. But a second class of writers must not be ignored, who, without laying claim to the rank of chief explorers or the merit of original discovery, have shown themselves fully capable of strengthening the revelations of the princes of African travel, by chronicling the results of their own lesser, yet always intelligent, nomadism. Of this class Mr. Werner is a good representative. His well-written narrative might well have won attention as a mere description of African river life, without the use of an *ad captandum* title in reference to "Rear Guards."

The author, accepting service as an engineer under the Congo State, embarked from Antwerp in April 1886, arrived at Banána late in May, passed up the river to Boma and Matádi (which has taken the place of Vivi on the left bank), and left the latter station for Stanley Pool, by land, on June 10. After many days of roughing and sickness, he reached the Pool station at Leopoldville, was detained there until the middle of July, and on August 1 came to a halt at Bangala, his prescribed head-quarters. This is one of the more northerly posts of the Free State, and is situated about a third of the way between the Equator and Stanley Falls stations. Here he was seldom allowed to rest for many weeks together; for the little steamer to which he was attached was in constant requisition. In fact, his river expeditions—at one time of a punitive or political, at another of a searching or scientific character—extending, in advance, to Stanley Falls, and, in rear, to Leopoldville, or limited to places within either distance—form the substance of his book.

Mr. Werner's official residence may be described in his own words:—

"Bangala Station stands on the north bank of the Congo, in the town of Iboko, which forms the centre of a ten-mile line of towns and villages inhabited by the Ba-Ngala tribe. This settlement is surrounded on three sides by swamp, and on the fourth the River Congo cuts off all communication except by boat. According to native accounts it is possible in the dry season to go some two days' journey inland; and I should think it quite practicable to penetrate as far as the Oubangi, but as the tribes on the bank of that river are hostile to the Ba-Ngala, I had no means of ascertaining the fact, and I have never been more than six or seven hours' journey in that direction myself. I found the country gently undulating—the rising ground for the most part cleared and cultivated, and the hollows filled with a dense scrub, which, in the wet season, grew out of three or four feet of water, sometimes more. After some three hours' journey inland, all cultivation ceases, and the path runs through one continuous jungle of scrub, there being very few large trees."

Vivid pictures of scenery are not wanting in these pages, and a chapter headed "Exploration of the Ngala," gives an account of a nine days' endeavour to test the navigability and uses of a feeder of the Congo which empties itself into the larger river about forty or fifty miles above Iboko. This expedition was, however, brought abruptly to an end by hostilities on the part of angry and warlike tribesmen. Mention is also made of a large lake supposed to exist in the regions between the Lower Lomami and the head of the Congo, and to be distant only one day's canoe journey from the former. Its appearance in the map accompanying Mr.

Werner's narrative presents a new geographical feature, the warrant for which has probably by this time been confirmed or disallowed. But the chief interest attaching to the book arises from the description of living persons, European or native, who take, or have taken, part in the story of the Congo Free State. The narrative may not always be as gratifying as truthful; nor is the record of that kind of warfare which tells us of the shooting of natives as though they were but large game, quite pleasant reading; but allowance must be made for unrecorded provocations and exigencies, and let us hope that conciliation will have a wider field for exercise when the harder obstacles to peaceful settlement shall have been removed. No civilized being could wish for the renewal of days such as those in which Mr. Werner "saw more than one poor wretch put up his shield, only just in time to receive a ball right through it and himself as well, and come rolling down the clay bank into the river, dead as a door-nail." The author has dwelt, moreover, upon a passage in his own particular career which cannot but leave a painful impression on the mind of his reader. He had been told that Tippoo Tip had threatened mischief to Major Barttelot if certain conditions were unfulfilled, and he had been restrained by circumstances from communicating intelligence of the threat to that gallant and lamented officer. It is easy to understand how this non-revelation of fore-shadowed ill haunted his brain, and how mental distress became aggravated by the sad news of Major Barttelot's death; but he may well derive consolation from the conviction that the reported threat was the outcome of a state of things which must have been fairly appreciated by all Europeans in those days encamped in the neighbourhood of Stanley Falls.

Mr. Werner is no doubt right in assuming that "facility of transport to the coast by means of railways and steamers will do more, by making slave-caravans unprofitable, to put down the curse of Africa," than the extinction of elephants—an hypothesis much favoured by recent writers. Were steam once made available for traffic along the main thoroughfares of the Dark Continent, the necessity for the employment of slaves in the conveyance of ivory would naturally cease, and one source of evil would thus be stopped by the mere force of circumstances—means quite as efficacious as, and more satisfactory than, armed intervention. In the final chapter the author considers with much intelligence and practical sagacity the different lines of communication now being opened out between the coast and the interior of Africa. These are notably, on the east, a land and water route from Uganda to the sea-mouth of the Tana River, passing through or skirting the possessions of the British East African Company: to the westward, the proposed railway to facilitate traffic between Banana and Stanley Falls; and, on the south, communications developing under the far from insignificant agency of the African Lakes Company. Truly, European enterprise is astir in the land; and England, the party most interested in the movement, if she remain content to be the most responsible speculator in its risks, should further seek to become the most important participator in its benefits.

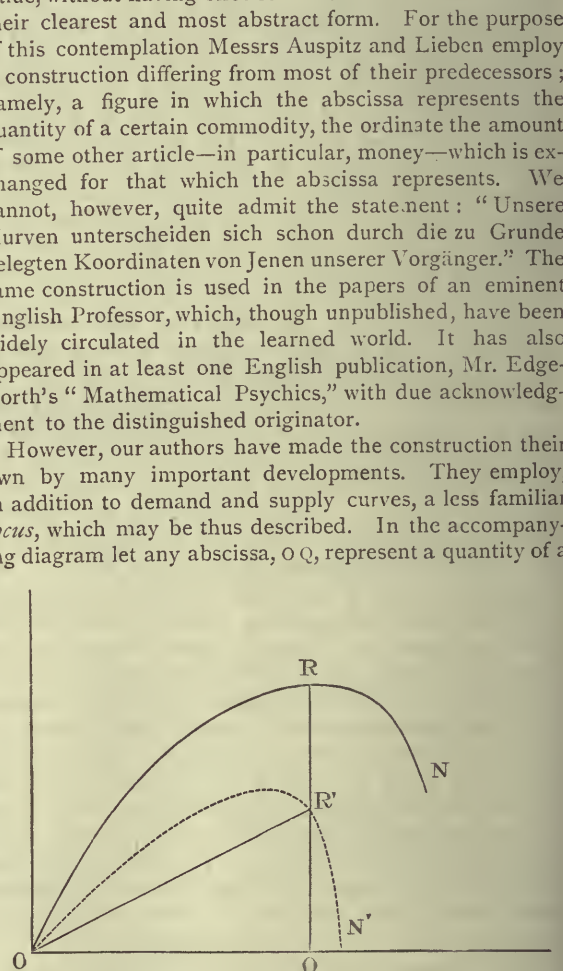
The attraction of this volume is enhanced by photographs and illustrations. Stanley's likeness is excellent, and the sketch of Mata Bwyki highly characteristic.

THE MATHEMATICAL METHOD IN POLITICAL ECONOMY.

Untersuchungen über die Theorie des Preises. Von Rudolf Auspitz und Richard Lieben. (Liepzig: Verlag von Duncker und Humblot, 1889.)

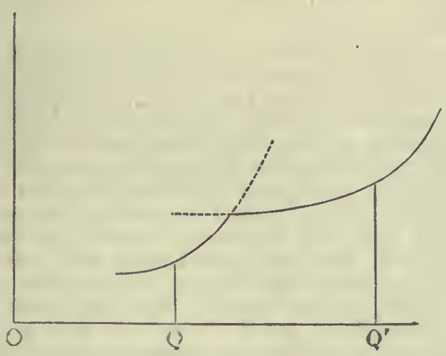
THE usefulness of mathematical reasoning applied to political economy, the value of the methods originated by Cournot and developed by Jevons, may be said to be still *sub judice*. The consideration of Messrs. Auspitz and Lieben's diagrams and symbols tends to confirm the opinion that mathematical analysis is a potent, if not an indispensable, means of obtaining clear general ideas in economics. The metaphysician who twists and turns the terms force and energy without grasping their mathematical signification is not more likely to become entangled in his talk than the practical man who reasons about supply and demand, and cost and value, without having once for all considered the ideas in their clearest and most abstract form. For the purpose of this contemplation Messrs Auspitz and Lieben employ a construction differing from most of their predecessors; namely, a figure in which the abscissa represents the quantity of a certain commodity, the ordinate the amount of some other article—in particular, money—which is exchanged for that which the abscissa represents. We cannot, however, quite admit the statement: "Unsere Kurven unterscheiden sich schon durch die zu Grunde gelegten Koordinaten von Jenen unserer Vorgänger." The same construction is used in the papers of an eminent English Professor, which, though unpublished, have been widely circulated in the learned world. It has also appeared in at least one English publication, Mr. Edgeworth's "Mathematical Psychics," with due acknowledgment to the distinguished originator.

However, our authors have made the construction their own by many important developments. They employ, in addition to demand and supply curves, a less familiar *locus*, which may be thus described. In the accompanying diagram let any abscissa, O Q, represent a quantity of a



certain commodity; and let Q R represent the amount of money which a consumer would be just willing to give in exchange for the commodity O Q: in such wise that it would be indifferent to him whether he procured O Q on such terms, or did not consume the article at all. The *locus* of this point O N is called the utility curve. Correlated with this primary curve is the demand curve O N', which indicates the amount which any individual is willing to purchase at the price represented by the tangent of the angle R′OQ. The advantage which the individual derives from that purchase is represented by the length of the line RR′—that is, supposing money to be a uniform measure of value, which would cease to be true when the transaction is on a very large scale: for instance, the payment of so much as QR would so cripple a person's resources as to render money a more important object to him, to alter his *Wertschätzung des Geldes*. Still, even in this general case, ON is regarded as a "curve of constant satisfaction," which we may describe as much the same as the "line of indifference" of the English publication to which we have referred. By a parity of construction we have the cost curve to represent the amount of money in return for which one would just be willing to produce a certain quantity of an article; and the offer or supply curve indicating the amount which the producer will offer at a certain price.

The curves which we have described represent primarily the effective dispositions of individuals. By superposition of such individualistic curves, we obtain corresponding *collective* curves. The intersection of the collective demand curve and the collective offer curve gives the price. On this point our authors' analysis throws some new light. They point out that most of the curves with which we have to deal are of the nature of an *envelope*, made up of a number of distinct *loci*. Consider the cost curve of the individual, for instance. His dispositions may be represented by two discrete curves, according as we consider different scales of production; say, hand-work and manufacture by machinery, corresponding to the neighbourhood of Q and Q′ respectively, in the accompanying figure. The outer portions of these lines, marked black



in our figure, form the genuine cost curve; from which a similarly composite offer curve may be derived. This sort of discontinuity has not been unnoticed by other writers, in the case of production. But we believe that Messrs. Auspitz and Lieben are the first writers who have maintained that the *locus* on the side of consumption is similarly composite; that the demand curve is made up of several bits, corresponding to different styles of life (*Lebensweise*).

It follows from these conceptions that the demand and supply curve, whose intersection determines price, must be of a simple shape, not re-entrant and crumple-horned, as they have sometimes been represented. Whence we may deduce that—theoretically, and on the supposition of enlightened self-interest—the price which tends to prevail in an ideal market is not only determinate, but unique. There cannot be, as it were, several solutions of the equations of exchange. The interest of this conclusion will be apparent when it is remembered that the contrary statement is advanced as important by Mill, with respect to international trade, and by Prof. Sidgwick, with respect to trade in general.

The curves employed by Messrs. Auspitz and Lieben assist us in conceiving a subject on which many misapprehensions exist—the gain of foreign trade. It takes Mill and Prof. Sidgwick a good many words to prove that it is possible for a country, by a judicious import or export tax, to benefit itself at the expense of the foreigner. The truth is seen much more easily, and in a higher degree of generality, by a glance at the appropriate mathematical diagrams.

The method also adapts itself to the dealings of a monopolist. The influence of a single large dealer in competition with several small ones is represented by a construction of peculiar beauty and originality. If it is true that we are drifting towards a *régime* of trusts, combinations, and monster establishments, surely any ray of new light on this somewhat unexplored field ought to be welcomed. It may be difficult, perhaps, to estimate the positive practical value of this use of the mathematical method. We might compare, perhaps, the function of the sovereign science in respect to the theory of monopolies, with the duties of government in respect to their management—to exercise a general supervision without attempting to control details.

Messrs. Auspitz and Lieben have also treated the case of monopoly in which an individual or combination deals with another economic unit. They of course see the point, which is often missed by the *littérateur*, that, without perfect competition, the determination of price is, within certain limits, indeterminate. On the question, what basis of arbitration—in the absence of the mechanical principle of competition—should prevail, we venture to regard their answer as much more profound than that which has been given by the most eminent English Professors. An agreement to the terms which afford the greatest sum total of utility will tend to come to pass. The utilitarian position thus indicated would coincide with the settlement towards which perfect competition tends, upon a certain condition which our authors have introduced. The condition may be described as proper to perfect competition; namely, that every portion of an article should be exchanged at the same rate. We are not satisfied that our authors are justified in predicating this condition of a bargain, such as that between an employer and a combination of workmen. Nor do we accept the implied optimistic conclusion that, in the abstract at least, the play of competition in the labour market tends to the arrangement which is the best possible for all concerned.

But we are sensible that on points so abstruse it is hardly possible to make our own meaning, or that of our authors, clear, without a more copious use of symbols and verbal explanation than would be here admissible. We regret, also, that, while indicating some salient features of the work before us, we have not been able to bring out the beauty and completeness of the whole. Perhaps no other piece of reasoning which has issued from the mathematical school of economics is so perfectly fitted together. No other of equal originality is equally easy to understand. The intellectual pleasure which is compounded of mathematical exertion and the interest in human affairs is here enjoyed must purely. F. Y. E.

PROFESSOR VON "CRANK."

Richtigstellung der in bisheriger Fassung unrichtigen Mechanischen Wärmetheorie und Grundzüge einer allgemeinen Theorie der Aetherbewegungen. Von Albert R. von Miller-Hauenfels, Professor a. D. in Graz. Pp. 256. (Wien: Manz'sche k.k. Hof-Verlags- und Universitäts-Buchhandlung, 1889.)

It is quite refreshing to come across a real "crank" among the sober Germans. As might be expected, there is a good deal of irregular metaphysics involved in the lucubrations of a German "crank." One would not, however, expect an entire ignorance of the first principles of the mathematics involved. The author of this hardly sufficiently ingenious to be even curious work begins by objecting to the well-known thermodynamic equation for perfect gases—

$$J(C - c) = p\frac{dv}{dt} = R = \frac{pv}{T},$$

because, forsooth, it is not identical with the general differential equation—

$$R = p\frac{dv}{dt} + v\frac{dp}{dt};$$

forgetting that the definition of C, as he himself gives it, assumes that, in the first equation, p is constant. In order to escape this invented difficulty, he loads himself with an equation—

$$JQ = Jcdt + vdp + pdv,$$

which involves the remarkable result that the heat required to warm a gas at constant volume is $JQ = Jcdt + vdp$, while by definition it is $= Jcdt$. It is not necessary to remark that the author carefully neglects to draw this conclusion. His equation is founded on the interesting principle that, when any event produces two different effects on the same organ of sense, each effect must be due to a separate flow of energy. When a mass of gas is warmed at constant volume, and one resists its expansion, one feels two effects with the same organ of sense: (1) the increase of pressure, and (2) the increase of temperature; and it is argued that each must be due to a separate flow of energy. This interesting principle leads to the startling conclusion that the heat required to change a body from one state to another, is independent of the states through which the body passes, and depends only on the initial and final states; and this startling oonclusion involves the equally startling inference that the internal energy of a body *is* a function of the states it has passed through. It would be very interesting to study the difference between water that had frequently passed through some cyclic process, and water which had not: no chemist has yet detected the difference.

It would be multiplying words without wisdom to go through the elaborate bolstering of hypothesis by assumption and unreason required to deduce any semblance to fact from these beginnings. It may however, be worth while to notice something in the second part of this work on the nature of the ether. It is assumed that Fresnel has conclusively proved that an ether consisting of molecules which repel one another would transmit transverse vibrations like light; and, in order to turn the difficulty of the existence of longitudinal vibrations to useful account, it is assumed that these latter exist and are heat. It is hardly necessary to investigate a theory of electric and magnetic forces founded upon such an ether, and upon some curious ideas as to forces flowing from place to place.

And what is the use of spending time looking into such a work as this? It is by studying extraordinary and startling departures from reason, and not the ordinary and familiar ones, that we learn the causes of our aberrations and how to avoid them. It is the same unreasoning prejudice for "I can hardly believe it otherwise," the same neglect to study the meanings of symbols, whether words or letters, the same satisfaction with a theory that leads to some true conclusions, which bristle upon every page of this book, and which are some of the most important factors in the prejudice that ignores the necessity for verification, the muddle-headedness that is content with vague notions, the clinging to an incomplete hypothesis that stands in the way of a true theory, all and each of which are in all and each of us such bars to progress. If the study of Prof. Miller-Hauenfels' errors leads to even a state of preparedness to look out for similar errors in our own work, the study will have been fruitful. G. F. F. G.

OUR BOOK SHELF.

Traité Encyclopédique de Photographie. By Charles Fabre. Vol. I., Part I. (Paris: Gauthier-Villars, 1889.)

This is the first part of an encyclopædic work on the history and development of photographic methods. Its general object is to set forth, not only full particulars of the methods now in actual use, but also a complete story of the gradual improvements which have led up to them. There is little doubt that the rapid progress which has been made in photography has been largely due to the fact that the whole subject is so new, that every investigator who sets himself to work soon becomes familiar with what has gone before, and is thus in a position to consider what further advances are possible. It is certainly not too much to expect that such a work as is contemplated by M. Fabre will do a great deal towards simplifying the acquirement of this knowledge.

It is proposed to issue the work in twenty monthly parts, of which five parts will constitute a volume. The first volume will treat more particularly of the general history of photography and photographic apparatus, special attention being given to the subject of lenses. The second volume will deal with the production of negatives, and the third with positives of every description. The fourth volume will first treat of the methods of enlargement, and then of photographic chemistry and theories of the formation of photographic images. This comprehensive scheme, if well followed out, as no doubt it will be, if we may judge by the excellence of the first part, will obviously constitute a valuable addition to photographic literature.

In the first part the whole subject of lenses is considered, from the chemical composition of the various kinds of glass employed in their construction to the various combinations now used. Spherical aberration, distortion, astigmatism, and chromatic aberration, and their remedies, are all fully considered. A useful bibliography is also appended to each chapter.

Les Levers Photographiques, et la Photographie en Voyage. By Dr. Gustave Le Bon. Part I. (Paris: Gauthier-Villars et Fils, 1889.)

THIS work treats of methods of obtaining by means of photography elevations and plans of monuments, buildings, &c., the intention being to render unnecessary the laborious tasks and long calculations which up to the present time have been unavoidable.

The modifications a camera has to undergo before operations are begun consist of the addition, first, of an india-rubber support fitted between the camera and the tripod, and, secondly, of a graduated ground glass in the place of a plain one. The india-rubber support is to enable the camera always to assume a horizontal position in whatever position the tripod may be; the ground glass thus being parallel to the face of the building which is about to be photographed. There is also an arrangement by which the camera can be rotated. By means of the ground glass the dimensions of objects can be easily measured, and horizontal and vertical angles can be read off.

The first few chapters relate to methods of graduating this glass, and its employment in the measurement of angular distances, also the mode of determining the focal lengths of the lenses employed, and the measurement of the sizes of objects after they have been photographed. Chapter v. treats of the general principles of photographic perspective, followed by the applications of those principles to the solutions of various problems, such as, "To determine the height of an inaccessible tower by a single photograph;" "To obtain without any measurement on the object itself its various dimensions," &c. Lastly, Chapter vi. deals with photographic triangulation and methods of measuring large base lines.

The International Annual of Anthony's Photographic Bulletin. Edited by W. J. Harrison, F.G.S., and A. H. Elliot, Ph.D., F.C.S. (London: Illiffe and Son, 1889.)

THIS is the second issue of an interesting and useful work. The number of articles has been considerably increased, and there is also an increase in the number of tables at the end, which will be of service both to professional and to amateur photographers. Various methods of printing are displayed in the illustrations. Two pretty views are given, one of which is taken with Dallmeyer's long-focus rapid landscape lens, and the other with his wide-angle landscape lens, showing well the effect of these different focus lenses. No pains seem to have been spared to make this issue surpass the first one, and the editors are to be congratulated on the results of their labours.

Industrial Education. By Sir Philip Magnus. (London: Kegan Paul, Trench, and Co.)

THE articles and addresses brought together in this volume form a valuable contribution to the study of one of the most important and interesting questions of the present day. Sir Philip Magnus has not attempted to exhaust his subject, or to deal with it systematically. He merely presents it from various points of view, offering suggestions as to the urgent need for a proper technical training, and as to the methods which may be most fitly used for the attainment of the ends in view. Every page bears witness not only to the writer's general knowledge and ability, but to his practical familiarity with all the aspects of the problems he discusses. One of the best papers in the book is that in which he gives an account of the school system of Bavaria, whose educational arrangements are not so well understood in this country as those of Prussia. No one who reads this paper, and takes into account all that has been done for education in the other States of Germany, will find much difficulty in explaining the fact that in industry and trade the Germans have become our most formidable competitors. Another excellent paper is on mercantile training, and there is also a good paper on technical instruction in elementary schools.

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.*]

An Index to Science.

I AM glad to see that Mr. Taylor Kay has again brought forward the question of a subject index to scientific periodicals. I say again, because the proposal to make such an index was suggested by me in a short letter in NATURE, vol. xviii. p. 251, and more fully at the first meeting of the Library Association at Oxford, in October 1878 (Transactions of Library Association, 1878, p. 85). Dr. Garnett also read a paper before the same Association on this subject in 1879, which was fully printed in NATURE, vol. xx. p. 554. In my original letter I suggested making the index from the papers themselves, and not from the Royal Society's Catalogue; my reason for this was the difficulty that must be experienced in indexing many papers, should the indexer have nothing but the title in front of him. Reference to the paper is absolutely necessary in many instances, especially when the title does not fully set forth its contents. Dr. Garnett, however, pointed out that much labour might be saved if the Royal Society would give two copies of its Catalogue of Scientific Papers, which might be cut up to form the copy of the subject-index. There can be no doubt that Dr. Garnett is right, because, by his plan, however many papers it might be necessary to refer to, the amount of labour as regards manuscript would be very materially diminished. The greatest difficulty of all is the money. Mr. Taylor Kay takes comfort in a Treasury Minute of November 1864, and hopes, from that, that help might be obtained from the Government. I am afraid, however, it will damp his ardour to be told that the Government have refused to bear the cost of printing the Catalogue for the decade 1874–83, although the matter is all ready for the press. It seems to me that, as suggested in my original paper, the co-operation of the learned Societies is the only way in which the necessary funds can be obtained.

I gather from Mr. Taylor Kay's paper that he rather suggests a "classified" list of papers. If that be so, I would like to protest against such an undertaking, feeling sure that it will, like all its predecessors, be doomed to failure. What is wanted is an index pure and simple, in which information can be turned up without consideration as to what "class" or "classes" the indexer has thought fit to enter the subject under. Anyone who has used the admirable catalogue of Dr. Billings will at once admit its superiority to any "classified" arrangement, whether it be that of Çomte or of any other philosopher.

The question of this index has been hanging fire too long, and I should be delighted if Mr. Taylor Kay's paper were the means of some active steps being taken to start the work. Poole's Index is a standing answer to those who say it cannot be done. All that we want are willing hands and a long purse: if the scientific Societies or an enterprising publisher will find the latter, I cannot believe the former will be wanting.

JAMES BLAKE BAILEY.

Royal College of Surgeons, July 5.

A Cordial Recognition.

I HAVE just witnessed a curious case of bird instinct which seems worth recording. A gardener living at Zukaleriá, three miles from here, caught in his garden a young but fully fledged sparrow, which he brought to the house of a friend with whom we are staying in Canea, leaving home early in the morning. He presented the bird to one of the children in the house, and it was put in a cage and hung at the window, where it seemed likely to be contented, losing its fright after a few hours. Late in the afternoon an old bird was noticed fluttering about the cage apparently trying to get at the little one, and the young bird on its appearance became frantic to get out to the old one. It was evidently the mother of the young one, as the recognition was too cordial to have been owing to the interest of a strange bird; and when my daughter opened the cage, as she did after a little, they both flew off rapidly in the direction of Zukaleriá. It is impossible that the old bird should have followed the gardener, as we should have seen it earlier in the day.

Canea, Crete, June 27. W. J. STILLMAN.

Seismology in Italy.

I HAVE only lately seen Dr. Johnston-Lavis's article in NATURE (vol. xxxix. p. 329), on the present state of seismology in Italy. I have read it with much interest, and with the greatest satisfaction, because it deals with the most recent works due to the new and serious impulse given to the study by the Government during the last five years. I thank the author for having noticed one of my writings, "Sulla sistemazione delle osservazioni geodinamiche regolari." There is little—hardly anything—absolutely new in this work, because in writing it I desired only to sum up the deliberations of the Royal Geodynamical Commission, to which I had the honour to belong. I also brought together in it all that was really serious and positive in other works, with the intention of dispelling the confusion which unhappily prevailed when this scientific branch was in the power of dilettantism, which had the prerogative of the long-winded style, the charlatanism, and the seismic magic, of which the author of the article justly complains. In a word, I wished to set forth a proper programme, with the ideas which the Commission conceived, and which continue to form the principle of the deliberations of the directing Council for Meteorology and Geodynamics, in which the Commission has been merged. On this serious and well-determined principle the service is continued in the island of Ischia as elsewhere.

In accordance with the just ideas of your correspondent, I must nevertheless make one remark on the subjects which relate more especially to the studies carried on in the island of Ischia; namely, that there is really something of novelty in some of the other writings of mine included in the volume that contains the work commented on.

One of these writings consisted of the theoretical relation I presented in response to the demand of the Royal Geodynamical Commission in the sittings of June 1886. The approval of this work by the Commission contributed to the adoption, for the study of the form of seismic movements, of the mechanical principle of three components adapted to a steady point. This principle was studied, and put into execution, by the mechanicians Brassart of the Central Office of Meteorology and Geodynamics; and while it has tended to simplify completely the methods used in the observation of earthquakes, and to bring to an end the innumerable imperfections of former times, it is not even yet well understood by men of the old school.

Three of my works relate to the variations observed in the temperature of the thermal springs at Porto d'Ischia. A rigorously mathematical analysis has revealed a hydrostatical law in relation to changes in the level of the sea. Later studies which I undertook upon the diagrams of a registering thermometer, and which the Director, Prof. Tacchini, presented to the Accademia dei Lincei on October 7, 1888, proved the influence exerted by the horary state of the tide, while previously some isolated observations had made way for hypotheses of another nature.

Another of my works expounds a new principle for rendering astatic—or nearly so—in a horizontal direction, the steady point in seismographs, and gives a mathematical demonstration of it. Upon this principle, which I conceived in 1886, is apparently based the construction of an instrument by Prof. Ames (see the *American Journal of Science*, February 1888, p. 106); but the fact that he has made the suspension with four threads, instead of three, suffices to prove that he has not formed a precise idea of my original principle, and that he has much less considered it necessary to procure for himself the mathematical proof of it. Some months before the publication of Mr. Ames's work I took care to bring out prominently, on p. 266 of the volume referred to, the error to which one would expose oneself in this way.

Of the ten writings by me in the volume, these are the works to which I attach some importance; and I take the liberty of directing to them the attention of your readers, in the hope of making known the beginnings of the success which is to be achieved through the action of the Italian Government. For the rest, the history of this enterprise is set forth in the abstract of the sittings which forms the introduction of the volume.

GIULIO GRABLOVITZ,
Director of the Osservatorio Geodinamico
di Casamicciola.

Saxicava Borings and Valves in a Boulder Clay Erratic.

WHEN examining a few weeks ago the boulders in the workings of the New Ferry Brick and Tile Company, Cheshire, with Mr. Harnett Harrisson, we discovered a boulder having superficially a scoriaceous appearance, which on examination proved to be of limestone, and perforated with Saxicava and other borings. After careful washing several of the burrows were found to be occupied by the shells of the animal that had made them, both valves complete. The washings that came out of the burrows after careful reduction by pouring off the clay water I found to consist of well-rounded grains of quartz intermixed with a few microscopic drift pebbles and small shell fragments. Some of them were very much rounded and waterworn. Several broken spines of Echinus also occurred.

The stone was taken from a heap picked out of the boulder clay previons to passing it through the machine. There is no doubt as to its origin, as one side is strongly planed and striated in the direction of the longer axis. The extreme measurements are $6\frac{1}{2}'' \times 4\frac{1}{2}'' \times 2\frac{3}{4}''$; weight, 3 lbs. 10 oz. The Saxicava burrows are placed so as to give the idea that the stone had lain on the glaciated side when most of them were made, as they get nearly horizontal towards the glaciated bottom. The termination of one burrow, however, occurs on the planed face. There are also other worm-like burrows which occur on the glaciated face, and one of them has been cut longitudinally for a length of an inch by the plane of glaciation.

It is now about eighteen years since I commenced a study of the glacial deposits of the north-west of England, but have never found a similar example with the burrows occupied, although the low-level boulder clay in which it occurs is almost universally more or less full of shell fragments. The bearing of the discovery on the origin of the low-level boulder clay is obvious.

The history of the stone appears to have been this. It had its origin in the Carboniferous limestone of the north; it has then been rounded into a boulder, has lain upon a shore, and become the seat of operations of molluscan and other burrowers. Afterwards it has been frozen into coast-ice, glaciated by attrition on a pebbly or rocky shore through tidal movement, has been again released from the ice grip, spent another time on the shore resting on its glaciated face, during which period it became perforated with the Saxicava burrows now occupied by the remains of the animal. While still on the shore, fragments of shells of other Mollusca got washed into the occupied and unoccupied perforations, and finally it was again frozen into coast-ice, floated off, and dropped into the bed of the low-level boulder clay sea, where it remained undisturbed until the pick of the brickmaker disinterred it. The boulder clay in which it occurs is plastic, and contains comparatively few stones, and there are no sand seams to be seen in the present face, though I believe they occur at a greater depth below the bottom of the pit.

The special interest of this example lies in the proof it affords of the marine origin of the low-level boulder clay of Cheshire and Lancashire. Some geologists contend that this clay is the bottom of the Irish Sea ploughed up by land ice, but the necessities of a theory that requires such an operation to have taken place in the past when there is an obvious and simple explanation at hand does not commend it to my mind. It is not even proved that such a ploughing up is possible; no examples are adduced where such a phenomenon is going on; it does not account for the structure of the beds of low-level boulder clay; and speaking from eighteen years of close investigation, there is no necessity in the nature of the case for resorting to such an extreme hypothesis.

The age of land ice preceded that of the low-level marine boulder clay, and numerous examples of striated rock surfaces and other phenomena occurring below the low-level marine boulder clay can be quoted in support thereof.

T. MELLARD READE.

Park Corner, Blundellsands, June 5.

Test of Divisibility by any Prime.

IN NATURE of May 30 (p. 115), Mr. Tucker has given the formula:—

$$N = 21M + 10^{n-1}(7Q) = 7Q'.$$

In an exactly similar way we may show that—

$N = 11M + 10^{n-1}(11Q) = 11Q'$, giving a multiplier 1,
$N = 91M + 10^{n-1}(13Q) = 13Q'$, ,, ,, 9,
$N = 51M + 10^{n-1}(17Q) = 17Q'$, ,, ,, 5,

&c., &c., for any number ending in digits 1, 3, 7, or 9.[1]

The general principle may be simply shown as follows:—

We have $17 \times 3 = 5 \cdot 1$, say.

This means (1) that, if *any number* ends in unity, and is also of Form 17M, then all the figures to the left of unity will form a number of Form 17M + 5.

It also means (2) that, if we *multiply the units digit* by 5 (casting out the prime 17, if need be), we get the figures to the left; *e.g.* 2346 ends in 6, and is of Form 17M. Therefore, 234 is of Form 17M + 13 (since $17 \times 8 = 13 \cdot 6$); also, $6 \times 5 = 30$, and $30 - 17 = 13$. The process can be repeated to any extent. Thus, since $234 = 17M + 13$, subtract 13 from 234, giving $221 = 17M_1$. Since 221 ends in unity, therefore 22 is of Form 17M + 5, and, subtracting 5 from 22, we have $17 = 17M_2$. Hence the rule.

From similar considerations I have deduced the following formula, giving the periodicity of $\frac{1}{N}$ where N is a prime:—

If $[\{(uN + 1)/10\}^p + N - 1]/N \equiv I$ (an integer), then p will be the periodicity of 1/N.

Here u means the unit's digit of N, or else the integral quotient of 9 divided by the unit's digit.

Thus for all numbers ending in 9 the formula becomes $[\{(N + 1)/10\}^p + N - 1]/N$, *e.g.* $(2^p + 18)/19$ gives the periodicity of 1/19, &c.

The corresponding formulæ for numbers ending in 7, 3, 1, are, respectively,

$$[\{(7N + 1)/10\}^p + N - 1]/N;\ [\{(3N + 1)/10\}^p + N - 1]/N;$$
$$[\{(9N + 1)/10\}^p + N - 1]/N.$$

Another useful deduction from the same principle is:—

If p be the periodicity of the recurring fraction 1/N (where N ends in 1, 3, 7, or 9), then the test will give the true remainder of any $p + 2$ figures; *e.g.* What is the remainder of $98765 \div 37$?

Since $37 \times 3 = 11 \cdot 1$, our multiplier is 11.

Therefore $9876 - 11 \times 5 = 9821$, and $982 - 11 \times 1 = 971$.

Also $97 - 11 \times 1 = 86 = 37M + 12$. Thus 12 is the remainder.

I find that by this new process the remainder may be obtained in about one-half of the time taken by the ordinary method of division.

ROBT. W. D. CHRISTIE.

Wavertree Park College, Liverpool.

QUARTZ FIBRES.[2]

IN almost all investigations which the physicist carries out in the laboratory, he has to deal with and to measure with accuracy those subtle and to our senses inappreciable forces to which the so-called laws of Nature give rise. Whether he is observing by an electrometer the behaviour of electricity at rest, or by a galvanometer the action of electricity in motion; whether in the tube of Crookes he is investigating the power of radiant matter, or with the famous experiment of Cavendish he is finding the mass of the earth—in these and in a host of other cases he is bound to measure with certainty and accuracy forces so small that in no ordinary way could their existence be detected; while disturbing causes which might seem to be of no particular consequence must be eliminated if his experiments are to have any value. It is not too much to say that the very existence of the physicist depends upon the power which he possesses of producing at will and by artificial means forces against which he balances those that he wishes to measure.

I had better perhaps at once indicate in a general way the magnitude of the forces with which we have to deal.

The weight of a single grain is not to our senses appreciable, while the weight of a ton is sufficient to crush the life out of anyone in a moment. A ton is about 15,000,000 grains. It is quite possible to measure with unfailing accuracy forces which bear the same relation to the weight of a grain that a grain bears to a ton.

To show how the torsion of wires or threads is made use of in measuring forces, I have arranged what I can hardly dignify by the name of an experiment. It is simply a straw hung horizontally by a piece of wire. Resting on the straw is a fragment of sheet-iron weighing ten grains. A magnet so weak that it cannot lift the iron yet is able to pull the straw round through an angle so great that the existence of the feeble attraction is evident to every one in the room.

Now it is clear that if, instead of a straw moving over the table simply, we had here an arm in a glass case and a mirror to read the motion of the arm, it would be easy to observe a movement a hundred or a thousand times less than that just produced, and therefore to measure a force a hundred or a thousand times less than that exerted by this feeble magnet.

Again, if instead of wire as thick as an ordinary pin I had used the finest wire that can be obtained, it would have opposed the movement of the straw with a far less force. It is possible to obtain wire ten times finer than this stubborn material, but wire ten times finer is much more than ten times more easily twisted. It is ten thousand times more easily twisted. This is because the torsion varies as the fourth power of the diameter, so we say $10 \times 10 = 100$; $100 \times 100 = 10,000$. Therefore with the finest wire, forces 10,000 times feebler still could be observed.

It is therefore evident how great is the advantage of reducing the size of a torsion wire. Even if it is only halved the torsion is reduced sixteen-fold. To give a better idea of the actual sizes of such wires and fibres as are in use I shall show upon the screen a series of photographs taken by Mr. Chapman, on each of which a scale of thousandths of an inch has been printed.

The first photograph (Fig. 1) is an ordinary hair—a sufficiently familiar object, and one that is generally spoken of as if it were rather fine. Much finer than this is the specimen of copper wire now on the screen (Fig. 2), which I recently obtained from Messrs. Nalder Brothers. It is only a little over one-thousandth of an inch in diameter. Ordinary spun glass, a most beautiful material, is about one-thousandth of an inch in diameter, and this would appear to be an ideal torsion thread (Fig. 3). Owing to its fineness its torsion would be extremely small, and the more so because glass is more easily deformed than metals. Owing to its very great strength, it can carry heavier loads than would be expected of it. I imagine many physicists must have turned to this material in their endeavour to find a really delicate torsion thread. I have so turned only to be disappointed. It has every good quality but one, and that is its imperfect elasticity. For instance, a mirror hung by a piece of spun glass is casting an image of a spot of light on the scale. If I turn the mirror, by means of a fork, twice to the right, and then turn it back again, the light does not come back to its old point of rest, but oscillates about a point on one side, which, however, is slowly changing, so that it is impossible to say what the point of rest really is. Further, if the glass is twisted one way first, and then the other way, the point of rest

[1] These numbers only can give, when multiplied, all the digits in the units place.

[2] Lecture delivered at the Royal Institution, on Friday, June 14, by Mr. C. V. Boys, F.R.S.

moves in a manner which shows that it is not influenced by the last deflection alone: the glass remembers what was done to it previously. For this reason spun glass is quite unsuitable as a torsion thread; it is impossible to

Scale of 1000ths of an inch for Figs. 1 to 7. The scale of Figs. 8 and 9 is much finer.

FIG. 1.

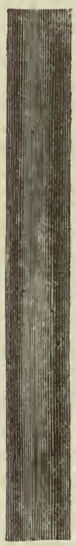


FIG. 2.

say what the twist is at any time, and therefore what is the force developed.

So great has the difficulty been in finding a fine torsion thread that the attempt has been given up, and in all the most exact instruments silk has been used. The natural

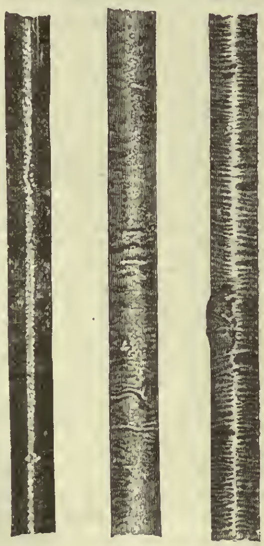


FIG. 3.

cocoon fibres, as shown on the screen (Fig. 4), consist of two irregular lines gummed together, each about one two-thousandth of an inch in diameter. These fibres must be separated from one another and washed. Then each component will, according to the experiment of Gray, carry nearly 60 grains before breaking, and can be safely loaded with 15 grains. Silk is therefore very strong, carrying at the rate of from 10 to 20 tons to the square inch. It is further valuable in that its torsion is far less than that of a fibre of the same size of metal or even of glass, if such could be produced. The torsion of silk, though exceedingly small, is quite sufficient to upset the working of any delicate instrument, because it is never constant. At one time the fibre twists one way, and another time in another, and the evil effect can only be mitigated by using large apparatus in which strong forces are developed. Any attempt that may be made to increase the delicacy of apparatus by reducing their dimensions is at once prevented by the relatively great importance of the vagaries of the silk suspension.

The result, then, is this. The smallness, the length of period, and therefore delicacy, of the instruments at the physicist's disposal have until lately been simply limited by the behaviour of silk. A more perfect suspension means still more perfect instruments, and therefore advance in knowledge.

It was in this way that some improvements that I was making in an instrument for measuring radiant heat came

FIG. 4.

to a deadlock about two years ago. I would not use silk, and I could not find anything else that would do. Spun glass, even, was far too coarse for my purpose; it was a thousand times too stiff.

There is a material invented by Wollaston long ago, which, however, I did not try because it is so easily broken. It is platinum wire which has been drawn in silver, and finally separated by the action of nitric acid. A specimen about the size of a single line of silk is now on the screen, showing the silver coating at one end (Fig. 5).

As nothing that I knew of could be obtained that would be of use to me, I was driven to the necessity of trying by experiment to find some new material. The result of these experiments was the development of a process of almost ridiculous simplicity which it may be of interest for me to show.

The apparatus consists of a small cross-bow, and an arrow made of straw with a needle point. To the tail of the arrow is attached a fine rod of quartz which has been melted and drawn out in the oxyhydrogen jet. I have a piece of the same material in my hand, and now after melting their ends and joining them together, an operation which produces a beautiful and dazzling light, all I have to do is to liberate the string of the bow by pulling the trigger with one foot, and then if all is well a fibre will have been drawn by the arrow, the existence of which can be made evident by fastening to it a piece of stamp-paper.

In this way threads can be produced of great length, of almost any degree of fineness, of extraordinary uniformity, and of enormous strength. I do not believe, if any experimentalist had been promised by a good fairy that he might have anything he desired, that he would have ventured to ask for any one thing with so many valuable properties as these fibres possess. I hope in the course of this evening to show that I am not exaggerating their merits.

In the first place, let me say something about the degree of fineness to which they can be drawn. There is now projected upon the screen a quartz fibre one five-thousandth of an inch in diameter (Fig. 6). This is one which I had in constant use in an instrument loaded with about 30 grains. It has a section only one-sixth of that of a single line of

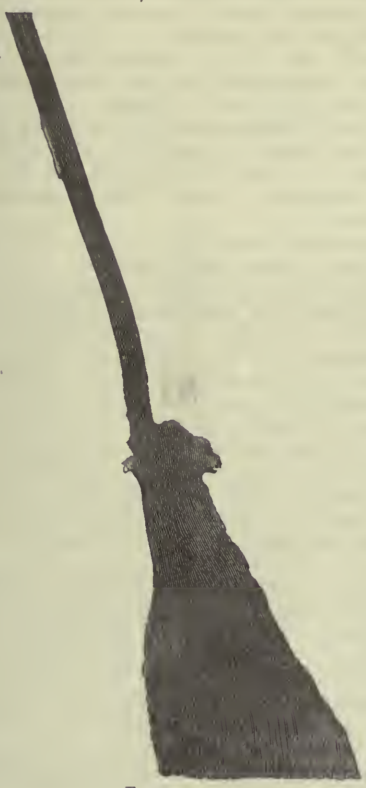


Fig. 5.

silk, and it is just as strong. Not being organic, it is in no way affected by changes of moisture and temperature, and so it is free from the vagaries of silk which give so much trouble. The piece used in the instrument was about 16 inches long. Had it been necessary to employ spun glass, which hitherto was the finest torsion material, then, instead of 16 inches, I should have required a piece 1000 feet long, and an instrument as high as the Eiffel tower to put it in.

There is no difficulty in obtaining pieces as fine as this yards long if required, or in spinning it very much finer. There is upon the screen a single line made by the small garden spider, and the size of this is perfectly evident (Fig. 7). You now see a quartz fibre far finer than this, or, rather, you see a diffraction phenomenon, for no true image is formed at all; but even this is a conspicuous object in comparison with the tapering ends, which it is absolutely impossible to trace in a microscope. The next two photographs, taken by Mr. Nelson, whose skill and resources are so famous, represent the extreme end of a tail of quartz, and though the scale is a great deal larger than that used in the other photographs, the end will be visible only to a few. Mr. Nelson has photographed here what it is absolutely impossible to see. What the size of these ends may be, I have no means of telling. Dr. Royston Piggott has estimated some of them at less than one-millionth of an inch, but whatever they are they supply for the first time objects of extreme smallness the form of which is certainly known, and therefore I cannot help looking upon them as more satisfactory tests for the microscope than diatoms and other things of the real shape of which we know nothing whatever.

Since figures as large as a million cannot be realized properly, it may be worth while to give an illustration of what is meant by a fibre one-millionth of an inch in diameter.

A piece of quartz an inch long and an inch in diameter would, if drawn out to this degree of fineness, be sufficient to go all the way round the world 658 times; or a grain of sand just visible—that is, one-hundredth of an inch long and one-hundredth of an inch in diameter—would make 1000 miles of such thread. Further, the pressure inside

Fig. 6. Fig. 7.

such a thread due to a surface tension equal to that of water would be 60 atmospheres.

Going back to such threads as can be used in instruments, I have made use of fibres one ten-thousandth of an inch in diameter, and in these the torsion is 10,000 times less than that of spun glass.

As these fibres are made finer their strength increases in proportion to their size, and surpasses that of ordinary bar steel, reaching, to use the language of engineers, as high a figure as 80 tons to the inch. Fibres of ordinary size have a strength of 50 tons to the inch.

While it is evident that these fibres give us the means of producing an exceedingly small torsion, and one that is not affected by weather, it is not yet evident that they may not show the same fatigue that makes spun glass useless. I have therefore a duplicate apparatus with a quartz fibre, and you will see that the spot of light comes back to its true place on the screen after the mirror has been twisted round twice.

I shall now for a moment draw your attention to that peculiar property of melted quartz that makes threads such as I have been describing a possibility. A liquid cylinder, as Plateau has so beautifully shown, is an unstable form. It can no more exist than can a pencil stand on its point. It immediately breaks up into a series of spheres. This is well illustrated in that very ancient experiment of shooting threads of resin electrically. When the resin is hot, the liquid cylinders which are projected in all directions break up into spheres, as you see now upon the screen. As the resin cools, they begin to develop tails; and when it is cool enough, *i.e.* sufficiently viscous, the tails thicken and the beads become less, and at last uniform threads are the result. The series of photographs show this well.

There is a far more perfect illustration which we have only to go into the garden to find. There we may see in abundance what is now upon the screen—the webs of those beautiful geometrical spiders. The radial threads are smooth like the one you saw a few minutes ago, but the threads that go round and round are beaded. The spider draws these webs slowly, and at the same time pours upon them a liquid, and still further to obtain the effect of launching a liquid cylinder in space he, or rather she, pulls it out like the string of a bow, and lets it go with a jerk. The liquid cylinder cannot exist, and the result is what you now see upon the screen (Fig. 8). A more perfect

Fig. 8.

Fig. 9.

illustration of the regular breaking up of a liquid cylinder it would be impossible to find. The beads are, as Flateau showed they ought to be, alternately large and small, and their regularity is marvellous. Sometimes two still smaller beads are developed, as may be seen in the second photograph, thus completely agreeing with the results of Plateau's investigations.

I have heard it maintained that the spider goes round her web and places these beads there afterwards. But since a web with about 360,000 beads is completed in an hour—that is, at the rate of about 100 a second—this does not seem likely. That what I have said is true, is made more probable by the photograph of a beaded web that I have made myself by simply stroking a quartz fibre with a straw wetted with castor oil (Fig. 9). It is rather larger than a spider line; but I have made beaded threads, using a fine fibre, quite indistinguishable from a real spider web, and they have the further similarity that they are just as good for catching flies.

Now, going back to the melted quartz, it is evident that if it ever became perfectly liquid it could not exist as a fibre for an instant. It is the extreme viscosity of quartz, at the heat even of an electric arc, that makes these fibres possible. The only difference between quartz in the oxyhydrogen jet and quartz in the arc is that in the first you make threads and in the second are blown bubbles. I have in my hand some microscopic bubbles of quartz showing all the perfection of form and colour that we are familiar with in the soap bubble.

An invaluable property of quartz is its power of insulating perfectly, even in an atmosphere saturated with water. The gold leaves now diverging were charged some time before the lecture, and hardly show any change, yet the insulator is a rod of quartz only three-quarters of an inch long, and the air is kept moist by a dish of water. The quartz may even be dipped in the water and replaced with the water upon it without any difference in the insulation being observed.

Not only can fibres be made of extreme fineness, but they are wonderfully uniform in diameter. So uniform are they that they perfectly stand an optical test so severe that irregularities invisible in any microscope would immediately be made apparent. Everyone must have noticed when the sun is shining upon a border of flowers and shrubs how the lines which spiders use as railways to travel from place to place glisten with brilliant colours. These colours are only produced when the fibres are sufficiently fine. If you take one of these webs and examine it in the sunlight, you will find that the colours are variegated, and the effect consequently is one of great beauty.

A quartz fibre of about the same size shows colours in the same way, but the tint is perfectly uniform on the fibre. If the colour of the fibre is examined with a prism, the spectrum is found to consist of alternate bright and dark bands. Upon the screen are photographs taken by Mr. Briscoe, a student in the laboratory at South Kensington, of the spectra of some of these fibres at different angles of incidence. It will be seen that coarse fibres have more bands than fine, and that the number increases with the angle of incidence of the light. There are peculiarities in the march of the bands as the angle increases which I cannot describe now. I may only say that they appear to move not uniformly but in waves, presenting very much the appearance of a caterpillar walking.

So uniform are the quartz fibres that the spectrum from end to end consists of parallel bands. Occasionally a fibre is found which presents a slight irregularity here and there. A spider line is so irregular that these bands are hardly observable; but as the photograph on the screen shows, it is possible to trace them running up and down the spectrum when you know what to look for.

To show that these longitudinal bands are due to the irregularities, I have drawn a taper piece of quartz by hand, in which the two edges make with one another an almost imperceptible angle, and the spectrum of this shows the gradual change of diameter by the very steep angle at which the bands run up the spectrum.

Into the theory of the development of these bands I am unable to enter: that is a subject on which your Professor of Natural Philosophy is best able to speak. Perhaps I may venture to express the hope, as the experimental investigation of this subject is now rendered possible, that he may be induced to carry out a research for which he is so eminently fitted.

Though this is a subject which is altogether beyond me, I have been able to use the results in a practical way. When it is required to place into an instrument a fibre of any particular size, all that has to be done is to hold the frame of fibres towards a bright and distant light, and look at them through a low-angled prism. The banded spectra are then visible, and it is the work of a moment to pick out one with the number of bands that has been found to be given by a fibre of the desired size. A coarse fibre may have a dozen or more, while such fibres as I find most useful have only two dark bands. Much finer ones exist, showing the colours of the first order with one dark band; and fibres so fine as to correspond to the white or even the gray of Newton's scale are easily produced.

Passing now from the most scientific test of the uniformity of these fibres, I shall next refer to one more homely. It is simply this: the common garden spider, except when very young, cannot climb up one of the same size as the web on which she displays such activity. She is perfectly helpless, and slips down with a run. After vainly trying to make any headway, she finally puts her hands (or feet) into her mouth, and then tries again, with no better success. I may mention that a male of the same species is able to run up one of these with the greatest ease, a feat which may perhaps save the lives of a few of these unprotected creatures when quartz fibres are more common.

It is possible to make any quantity of very fine quartz fibre without a bow and arrow at all, by simply drawing out a rod of quartz over and over again in a strong oxyhydrogen jet. Then, if a stand of any sort has been placed a few feet in front of the jet, it will be found covered with a maze of thread, of which the photograph on the screen represents a sample. This is hardly distinguishable from the web spun by this magnificent spider in corners of greenhouses and such places. By regulating the jet and the manipulation, anything from one of these stranded cables to a single ultra-microscope line may be developed.

And now that I have explained that these fibres have such valuable properties, it will no doubt be expected that I should perform some feat with their aid which, up to the present time, has been considered impossible, and this I intend to do.

Of all experiments the one which has most excited my admiration is the famous experiment of Cavendish, of which I have a full-size model before you. The object of this experiment is to weigh the earth by comparing directly the force with which it attracts things with that due to large masses of lead. As is shown by the model, any attraction which these large balls exert on the small ones will tend to deflect this 6-foot beam in one direction, and then if the balls are reversed in position the deflection will be in the other direction. Now, when it is considered how enormously greater the earth is than these balls, it will be evident that the attraction due to them must be in comparison excessively small. To make this evident the enormous apparatus you see had to be constructed, and then, using a fine torsion wire, a perfectly certain but small effect was produced. The experiment, however, could only be successfully carried out in cellars and underground places, because changes of temperature produced effects greater than those due to gravity.[1]

Now I have in a hole in the wall an instrument no bigger than a galvanometer, of which a model is on the table. The balls of the Cavendish apparatus, weighing several hundredweight each, are replaced by balls weighing $1\frac{3}{4}$ pound only. The smaller balls of $1\frac{3}{4}$ pound are replaced by little weights of 15 grains each. The 6-foot beam is replaced by one that will swing round freely in a tube three-quarters of an inch in diameter. The beam is, of course, suspended by a quartz fibre. With this microscopic apparatus, not only is the very feeble attraction observable, but I can actually obtain an effect eighteen times as great as that given by the apparatus of Cavendish, and, what is more important, the accuracy of observation is enormously increased.

The light from a lamp passes through a telescope lens, and falls on the mirror of the instrument. It is reflected back to the table, and thence by a fixed mirror to the scale on the wall, where it comes to a focus. If the mirror on the table were plane, the whole movement of the light would be only about 8 inches, but the mirror is convex, and this magnifies the motion nearly eight times. At the present moment the attracting weights are in one extreme position, and the line of light is quiet. I will now move them to the other position, and you will see the result—the light slowly begins to move, and slowly increases in movement. In forty seconds it will have acquired its highest velocity, and in forty more it will have stopped at 5 feet $8\frac{1}{2}$ inches from the starting-point, after which it will slowly move back again, oscillating about its new position of rest.

It is not possible at this hour to enter into any calculations; I will only say that the motion you have seen is the effect of a force of less than one ten-millionth of the weight of a grain, and that with this apparatus I can detect a force two thousand times smaller still. There would be no difficulty even in showing the attraction between two No. 5 shot.

And now, in conclusion, I would only say that if there is anything that is good in the experiments to which I have this evening directed your attention, experiments conducted largely with sticks, and string, and straw and sealing-wax, I may perhaps be pardoned if I express my conviction that in these days we are too apt to depart from the simple ways of our fathers, and, instead of following them, to fall down and worship the brazen image which the instrument-maker hath set up.

[1] Dr. Lodge has been able, by an elaborate arrangement of screens, to make this attraction just evident to an audience.—C. V. B.

A NEW SCHOOL OF ORIENTAL STUDIES.

THE Imperial Institute has taken a most important step towards the organization of higher commercial education in London, by effecting an arrangement between University and King's Colleges for the establishment of a new School for Oriental Studies. The close connection between the mercantile interests of this country and of India, Turkey, China, South Africa, and other lands, renders it very desirable that travellers and traders should have full facilities for acquiring, not only a knowledge of the languages of those countries, but also some acquaintance with the habits and customs of the inhabitants. In France and Germany, we find that the wants of this class of students have been fully recognized by the State. The French School of Oriental Languages has been in existence over 100 years, and has recently been reconstructed at an annual expense, for maintenance alone, of £6000; and in 1887 a new school was opened in Berlin, as a special department of the University, which receives a subvention from the Government of over £3000 a year. In England, the economy to the nation of adequately supporting institutions for higher education is not yet understood, and consequently private effort has to step in and relieve the State of a duty which in other countries is discharged in no niggard spirit. The new School of Oriental Studies promises to supply a distinct want. Instruction will be given in the principal Indian languages, in Persian, Burmese, Malay, Arabic, Turkish, Russian, Modern Greek, Chinese, Japanese, and Swaheli. The students will be taught not only to read and write, but also, as far as is possible, to speak those languages; and to this end the Committee contemplate the appointment of native readers and teachers of conversation. It has already been arranged that some of the Professors will preface their courses of linguistic teaching by lectures on the history, the physical and commercial geography, and the economic condition of the countries in which the various languages are spoken. It is hoped that by such means our mercantile and official classes may have the opportunity of acquainting themselves with the life and thought of the different Eastern peoples with whom they may be brought into communication.

The Imperial Institute is to be congratulated on having succeeded in bringing into harmonious working the two London Colleges, to each of which has for many years been attached a staff of eminent Professors of Oriental languages. The Indian School of University College, and the Oriental Section of King's College, have both done useful work; but, mainly from want of proper organization, the classes of many of the Professors have been but poorly attended, and several important modern languages a knowledge of which is now needed have not been included in the prospectus of either school. The Institute has effected an arrangement with the Colleges whereby the Indian and some allied tongues will continue to be taught in Gower Street, whilst the other languages will be taught at King's College, Strand. This is perhaps the first instance of such an arrangement between the two Colleges having been brought about, and suggests the practical advantage of an extension of the system to other branches of learning. It is only by a proper organization of the higher instruction that London can secure the full advantages of University education, and it may be hoped that as soon as a teaching University can be established in London, the two Colleges and the Medical and Science Schools will be found to co-operate with one another, so as to supplement, without unduly interfering with, each other's field of work.

We should add that the new School of Oriental Studies, which will be opened in October next, is under the general management of a special Committee, which comprises among its members Sir Francis Bell, Sir Charles Wilson, Sir Thomas Wade, Sir Frederic Goldsmid, and representatives of the governing bodies and teaching staffs of the two Colleges.

NOTES.

THIS year the French Association for the Advancement of Science will hold its annual meeting in Paris. The session will last from August 8 to 14. A great number of members are expected to attend the meeting, and it is hoped that many foreign men of science may also be present.

THE International Congress which met in Paris in 1887 to make arrangements for the preparation of a photographic chart of the heavens expressed a wish that a similar Congress might meet for the discussion of questions relating to celestial photography in general. M. Janssen and Mr. Common were asked to take such steps as might be necessary for the attainment of this object; and afterwards, by a Ministerial decision at Paris, an organizing Committee, with M. Janssen as President, was appointed. The arrangements have now been completed, and the Congress will be held in Paris from August 22 to September 3. The aim of the Congress will be to determine the methods which are most suitable for each branch of celestial photography, and the means by which the results obtained by these methods can be most effectually published and preserved.

THE Botanical Society of France announces the following programme of the forthcoming Botanical Congress to be held in Paris:—Tuesday, August 20: opening sitting of the Congress at 2 p.m., at the hotel of the Horticultural Society, 84 Rue de Grenelle; reception of foreign members at 8.30 p.m. Wednesday, August 21: sitting at 9 a.m., devoted to the consideration of the first question, on the utility of an agreement between the different Botanical Societies and Museums, for the purpose of drawing up charts of the distribution of species and genera of plants on the globe; and other communications, if time allows. Thursday, August 22: excursion in the neighbourhood of Paris. Friday, August 23: sitting at 9 a.m., devoted to the consideration of the second question, on the characters furnished by anatomy for classification; and other communications, if time allows. In the afternoon a visit to the botanical collections and laboratories of the Museum of Natural History, and of the other large scientific establishments in Paris. Saturday, August 24: sitting at 9 a.m., miscellaneous contributions. In the afternoon a visit to the Exhibition. Sunday, August 25: banquet to the foreign botanists. During the following week several botanical excursions will also be arranged. Special arrangements with regard to railway fares will be made in favour of botanists announcing their intention to be present to M. P. Maury, the Secretary to the Committee of Organization, 84 Rue de Grenelle, before July 25.

THE following are subjects proposed for discussion at the International Zoological Congress, to be held in Paris (August 5–10):—Adoption of rules on the nomenclature of organisms, and of an international scientific language; determination of regions the fauna of which calls for investigation; methods of investigation and procedure in preparation and preservation of animals; the use of embryology in classification; relations between living and fossil fauna. The Secretary's address is 32 Rue de Luxembourg.

AT the International Congress on Hygiene and Demography, also to be held during the Paris Exhibition, there will be discussed:—The administrative and medical regulations framed in different countries in the interests of health and of infantile life; removal and utilization of solid detritus in cities and the country; regulation and distribution of temperature in the dwelling; action of the soil on germs of disease; protection of watercourses and of ground water from pollution by factory refuse; sanitation of ports; accidents through food-stuffs of animal origin containing poisonous alkaloids; statistics of the causes of death in cities.

SOME valuable reports were distributed among the members of the International Agricultural Congress, which finished its labours at Paris the other day. One of them relates to agricultural education. This report is signed by a dozen authors, among whom are MM. Tisserand, Prilleux, and Jamieson, the latter an Englishman.

THE sixty-second meeting of German Naturalists and Physicians will be held at Heidelberg from September 17 to 23. One whole day will be devoted to excursions in the neighbourhood, and on the evening of September 23 the Castle of Heidelberg will be brilliantly illuminated.

AT a meeting of the Council of Dundee University College, held on the 3rd instant, Mr. J. Martin White announced that he had been authorized by Mr. John Bett, merchant, Rohallion, to offer a third of the amount required to found and establish a Chair of Physiology in connection with the Medical School of the College, provided the remaining two-thirds of the amount required be raised. It was mentioned that, to provide a fund adequate for the endowment of the Chair and the furnishing of suitable buildings and equipment, a sum of about £15,000 would be necessary. The foundation of this Chair would enable the College to complete the first two years of a medical curriculum.

A CIRCULAR from Harvard College Observatory, dated June 26, states that the sum of fifty thousand dollars has been received by that Observatory from Miss C. W. Bruce, of New York, to be applied "to the construction of a photographic telescope having an objective of about 24 inches aperture with a focal length of about 11 feet; . . . also to secure its use under favourable climatic conditions in such a way as will best advance astronomical science."

A STATUE of Paul Bert was unveiled at Auxerre on Sunday last. The ceremony was attended by the Annamite Envoys, and M. Spuller represented the French Government.

DR. E. HEINRICHER has been appointed Professor of Botany and Director of the Botanical Garden at Innsbrück; and Dr. H. Ambronn, Professor of Botany at Leipzig.

THE number of working botanists in Portugal is so small that it is with great satisfaction we are able to announce the appointment of Dr. G. von Lagerheim of Stockholm, recently of Freiburg-i-B., as assistant in the botanical laboratory of the Polytechnic School at Lisbon.

IT is stated that the Imperial Museum of Vienna has accepted the eccentric conditions of the bequest of the late Prof. H. G. Reichenbach, of Hamburg, according to which his extensive collection of dried orchids and drawings of orchids shall be placed in sealed packets in the Museum, and shall not be exhibited or in any way used within twenty-five years of his death.

THE *Kew Bulletin* for July consists of an excellent guide to the botanical literature of the British Empire. The primary object of the compilation is to supply useful information on the literature of the systematic, economic, and geographical botany of British Possessions, Dependencies, and Protectorates. The compiler explains that Kew is often called upon to answer questions, on the shortest notice, concerning the vegetation of some remote part of the world, and the best books to consult on the subject. Such questions are not always easily answered, and they frequently entail a considerable expenditure of time. The intention is that the present guide shall supply what is wanted, and everyone who may have occasion to use it will find that it is admirably adapted to its purpose.

MR. THOMAS SCOTT, of the Scientific Department of the Scottish Fishery Board, on June 27, in the Moray Firth, successfully fertilized the ova of the lemon sole (*Pleuronectes microcephalus*) with the milt of the turbot (*Rhombus maximus*). Development proceeded rapidly for three days and a half, when the ova were killed by dust getting into the water, and they sank. At this period the embryo was well formed, development was going on quickly, and hatching would probably have occurred on the seventh or eighth day.

LAST week, the Rev. W. S. Green, Mr. W. de Vismes Kane, and other zoologists, had a successful trawling expedition in the Atlantic, off the Irish coast. They started from Queenstown, in the *Flying Fox*, on Monday, July 1, and returned on Sunday. All the captures were divided and subdivided into different classes, carefully preserved in spirits, and packed in the cases which were used in the *Challenger* Expedition; and they have been forwarded to the Natural History Department of the British Museum, for whose benefit the expedition was organized.

MISS MARIA MITCHELL, well known as a writer on astronomy, died recently in New York. She was the daughter of William Mitchell, astronomer, and was born in Nantucket, Massachusetts, on August 1, 1818. In 1847 she made the discovery of a comet, for which she received a gold medal from the King of Denmark, and other distinctions. During a visit to Europe, in 1858, she was the guest of Sir John Herschel and Sir George B. Airy, and afterwards she visited Leverrier in Paris and Humboldt in Berlin. In 1865 she was called to the Professorship of Astronomy at Vassar College, which, with the post of Director of the Observatory, she retained until January 1888, when she secured a long leave of absence. The degree of LL.D. was conferred upon Miss Mitchell by Hanover College in 1852, and by Columbia College in 1887. She was a member of various scientific Societies, and was the first woman elected to the American Academy of Arts and Sciences. She contributed numerous articles to scientific journals.

THE heat in Russia and other parts of Northern Europe has been intense of late. The Central Observatory at St. Petersburg has not recorded such a high temperature at the same time of the year since 1774.

A SHOCK of earthquake occurred at Guernsey on Monday afternoon, about 2.30. It was not quite so violent as that experienced on May 30. The weather during the whole of the morning was extremely sultry.

ON the evening of January 31 last, about 9 o'clock, the self-recording barometer at the Deutsche Seewarte showed a sudden dip of about 0·04 inch, with a corresponding jump upwards a few minutes afterwards; and in the course of a day or two it was found that the barographs at other stations exhibited a similar phenomenon. Although the disturbance cannot be compared in any way to the air-wave caused by the Krakatão eruption, yet the rapidity of its translation proved it to be a noteworthy meteorological phenomenon, and its behaviour over Central Europe is discussed in an article contributed to the *Annalen der Hydrographie und maritimen Meteorologie* for June, by Dr. E. Herrmann, of the Deutsche Seewarte. The disturbance is traced from Keitum (lat. 54° 54′), where it occurred at 7h. 50m. p.m., Berlin time, on January 31, to Pola (lat. 49° 42′), which it reached at 4h. 38m. a.m. on February 1, having travelled at the rate of about 71 miles per hour. In an easterly and westerly direction the disturbance seems to have been confined to narrow limits. The barometer was high over Southern Europe (30·5 in.), with minima (28·7 in.) over Northern Finland, and between Iceland and Norway. There was no earthquake in Europe at the time, and the cause of the phenomenon remains at present unexplained.

PÈRE CHEVALIER, S.J., Director of the Sikawei Meteorological Observatory, near Shanghai, has issued his monthly Bulletin for August last. It is an unusually interesting number, as it contains a full study, with diagrams, of the two typhoons which were felt at Shanghai and in the south of China. These elaborate studies of the typhoons of the China seas are invaluable, especially when supplemented by the labours of Dr. Doberck, of Hong Kong; of the Japan Observatory; and of that of Manilla, in the Philippine Islands. Père Chevalier has a number of charts showing the tracks of the storms.

THE Committee of the General Board of Studies of the Victoria University of Manchester have issued their report on local lectures during the past three sessions 1886-87 to 1888-89. Twenty courses of local lectures have been delivered, and the Committee state that they have every reason to be satisfied with the results obtained so far. The subjects selected have been very varied, ranging over many branches of literature and science. The local Committees have been of very different constitution, including Committees specially formed for the purpose of the lectures, Literary and Philosophical Societies, mechanics' institutes, and educational institutions of various grades; and the audiences, while mainly drawn from the middle classes, have in some cases consisted entirely of working men. The attendance at the lectures has been well maintained, averaging for all courses about 130.

IN the forty-third Annual Report of the Commissioners in Lunacy, just issued, it is stated that there were, on New Year's Day, 84,340 insane persons under restraint. Of these, 7970 were of the private class, 75,632 were paupers, and 738 were criminals. The Commissioners believe that during recent years medical men have become increasingly unwilling to certify to the insanity of persons requiring treatment, in consequence of the results of recent litigation connected with this part of their duties. The causes of insanity are set forth in a table covering 136,478 cases. These are very diverse. Thus 9569 persons lost their reason from domestic trouble, 8060 from adverse cicumstances, 8278 from over-work and worry, 3769 from religious excitement, and 18,290 from intemperance. The influence of heredity was ascertained in 28,063 cases, and congenital defect in 5881.

A Bill has been introduced into the House of Commons which would, if it became law, prove a great boon to young people in the rural districts. The object is to provide instruction in agricultural and horticultural subjects in public elementary schools, and to afford practical illustration in such teaching. The Industrial Agricultural Education Bill, as it is called, would not only secure for children in rural districts practical instruction on such subjects as fruit, flowers, and vegetable growing, the proper method of keeping cattle, rotation of crops, packing fruit for market, and other matters of equal importance: it proposes, further, that the instruction in these branches shall be carried on after the children leave school. To effect this it is proposed to establish schools at which lessons would be given in the evenings, and on Saturday afternoons. To induce parents to keep their children at school for a longer period, or to send them to the new schools, the promoters of the measure advocate the provision of a small number of scholarships of the value of thirty shillings per annum, and tenable for two years, for children who have passed the fourth standard. They foresee, also, that the ordinary appliances of elementary schools will not be sufficient to secure comprehensive instruction in practical agriculture, and they are bold enough to hope that a special grant will be made by the Education Office or the Science and Art Department for the expenses of such allotments, school gardens, and buildings as may be necessary to make the teaching thoroughly practical. The Bill is backed by Mr. George Dixon, Mr. Henry Fowler, Sir John Lubbock, Mr. Jesse Collings, Sir Bernhard Samuelson, Mr. Howell, Sir John Kennaway, Mr. Robert Reid, and Major Rasch.

Messrs. Trübner and Co. will publish, probably in October, "An Account of the Aborigines of Tasmania, their Manners, Customs, Wars, Hunting, Food, Morals, Language, Origin, and General Characteristics," by Henry Ling Roth, assisted by E. Marion Butler. The work will contain a chapter on the osteology, by Dr. J. G. Garson, and a preface will be contributed by Dr. E. B. Tylor. Numerous autotype plates, from original drawings made by Edith May Roth, will illustrate the text. The edition will be strictly limited to subscribers.

The Delegates of the Clarendon Press will shortly issue Mr. Oliver Aplin's "Birds of Oxfordshire"; the second volume (treating of electro-dynamics) of Messrs. Watson and Burbury's "Mathematical Theory of Electricity and Magnetism"; and a new edition of the fourth volume (on the dynamics of material systems) of Prof. Bartholomew Price's "Treatise on Infinitesimal Calculus."

In the new number of the *Internationales Archiv für Ethnographie* (Band ii., Heft 3) Mr. Felix Driessen gives an interesting account, in English, of tie and dye work, manufactured at Semarang, Java. The article is accompanied by a plate representing the manufacture in all its different stages. Mr. R. Parkinson continues his excellent notes, in German, on the ethnology of the Gilbert Islanders. The valuable German paper, by Dr. F. von Luschan, on a Turkish "Schattenspiel," is also continued. The number, like its predecessors, has many notes on ethnographical museums, collections, and books.

The Department of Mines, Sydney, has issued the first number of what promises to be a valuable publication—*Records of the Geological Survey of New South Wales*. It opens with "Notes on the Geology of the Barrier Ranges District and Mount Browne and Tibooburra Gold Fields," by Mr. C. S. Wilkinson. Messrs. T. W. E. David and R. Etheridge, Jun., contribute an interesting report on the discovery of human remains in the sand and pumice bed at Long Bay, near Botany. There are other papers by the same writers, and by Mr. W. Anderson, Mr. J. C. H. Mingaye, and Mr. H. W. Powell.

Messrs. George Philip and Son have issued the third volume of the well-known series, "Rustic Walking Tours in the London Vicinity." It deals with the west-to-south district, and contains a field-path map, a geographical description, forty-five charts, with ample and plain directions, and an index.

A little book called "Walks in Holland," edited by Mr. Percy Lindley, has just been issued. It presents concisely much information that may be of service to tourists.

The other day the plough of a peasant in the island of Gothland unearthed a valuable treasure, consisting of two large spiral armlets, a buckle, and a long bar used in payment, all of solid silver, together with nearly 400 silver coins. Some of the coins were Anglo-Saxon, and bore the effigy of King Ethelred. The others were German and Cufic coins. The "find" has been purchased by the State.

The richness of the cod fisheries this spring on the coast of Finmarken has clearly shown that these fisheries are not in the least affected by whales. The Government has voted a sum of £850 towards the cost of a Commission for dealing with the much-needed protection of the whale.

The preservation of the eider in Sweden is to be extended from April 24 to May 31. Through strict protection these valuable birds have increased greatly in recent years along the Baltic and the Cattegat.

Dr. Schweinfurth has presented a valuable collection of plants from Yemen to the Christiania Museum.

The late Mr. Wilson, of Gothenburg, has left a legacy of £5500 to that city for the promotion of science, art, and education. He has also left his valuable collections to the Gothenburg Museum. A few years ago Mr. Wilson endowed this institution with a similar sum.

The Finnish naturalist, Dr. J. Kinunen, has set out on a voyage of scientific research to Nova Zembla and adjacent parts.

A new series of double oxalates of the rare metal rhodium and the metals of the alkalies or alkaline earths are described by M. Leidié in the July number of the *Annales de Chimie et de Physique*. The hydrate of rhodium sesquioxide, $Rh_2(OH)_6$, a substance having the peculiar appearance of a black jelly, and which is but slightly attacked by most acids, dissolves readily, when recently precipitated, in a concentrated solution of oxalic acid. On evaporation of this solution, containing presumably rhodium oxalate, no crystalline oxalate is obtained, but only a non-crystallizable transparent mass. If, however, this solution is evaporated along with a solution of neutral oxalate of potassium, sodium, or ammonium, on cooling beautiful garnet-red crystals of a double oxalate are deposited, containing one molecule of the oxalate of rhodium sesquioxide and three molecules of the alkaline oxalate. The potassium salt, $Rh_2(C_2O_4)_3 . 3C_2K_2O_4 . 9H_2O$, separates from solution in red triclinic prisms, very soluble in water. The largest crystals are obtained from a perfectly neutral solution, and may be most readily prepared by saturating a boiling solution of acid potassium oxalate with recently precipitated hydrate of rhodium sesquioxide. It is an evidence of the strength of the combination that the solution gives none of the characteristic tests for rhodium, not being precipitated either by potash or soda, and only partially by sulphuretted hydrogen. The ammonium compound $Rh_2(C_2O_4)_3 . 3C_2(NH_4)_2O_4 . 9H_2O$ is isomorphous with the potassium salt, and crystallizes in smaller red prisms. It is soluble in its own weight of warm water. On the other hand, the sodium salt crystallizes with $12H_2O$, in red prisms which are very efflorescent. The salts containing the alkaline earthy metals are much less soluble, and are generally obtained as crystalline precipitates by decomposition of the potassium salt by the chloride of the metal which it is desired to introduce. It is interesting that these salts are perfectly analogous to the double oxalates of ferric iron and chromium, $Fe_2(C_2O_4)_3 . 3C_2(NH_4)_2O_4$, for instance; but the two series are not isomorphous owing to the difference in water of crystallization. Evidence of similarity between iron and rhodium is of course shown by the fact that their most stable chlorides are those derived from the sesquioxides—namely, Fe_2Cl_6 and Rh_2Cl_6; but the formation of these double oxalates shows that the connection is perhaps closer than has hitherto been supposed. And the interest in this connection is by no means lessened by the fact that iron and rhodium occupy corresponding positions in the eighth vertical group of Prof. Mendeleeff's periodic classification.

THE additions to the Zoological Society's Gardens during the past week include two Indian Jerboas (*Alactaya indica*) from India, presented by Mr. Cuthbert Johnson; a Bonnet Monkey (*Macacus sinicus* ♀, white variety) from India, presented by the Waterbury Watch (Sales) Company, Limited; a Lesser White-nosed Monkey (*Cercopithecus petaurista* ♀) from West Africa, presented by Captain Stewart Stephens; a Brown Bear (*Ursus arctos* ♀), European, presented by Mr. John Foster Spence; a Polar Bear (*Ursus maritimus* ♀) from Spitzbergen, presented by Mr. Arnold Pike; a Python (sp. inc.), presented by Mrs. Bertha M. L. Bonser; a Hybrid Wild Swine (between *Sus scrofa* and *Sus domesticus* ♀) from Spain, presented by Mr. Ralph Banks, F.Z.S.; a Brush-tailed Kangaroo (*Petrogale penicillata* ♂) from New South Wales, presented by Sir Edmund A. H. Lechmere; five Violaceous Night Herons (*Nycticorax violaceus*) from St. Kitt's, W.I., presented by Dr. A. P. Boon, C.M.Z.S.; twelve Aldrovandi's Skinks (*Piestiodon auratus*) from North Africa, two Barnard's Parrakeets (*Platycercus barnardi*) from South Australia, purchased; a Laughing Kingfisher (*Dacelo gigantea*) from Australia, deposited; two Wonga Wonga Pigeons (*Leucosarcia picata*) from New South Wales, and a Red-winged Parrakeet (*Aprosmictus erythropterus*) from Australia, received in exchange; an African Wild Ass (*Equus tæniopus* ♀), and a Collared Fruit Bat (*Cynonycteris collaris*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE LATE PROF. CACCIATORE.—Prof. G. Cacciatore, whose death we have briefly recorded (p. 208), had been associated with the Royal Observatory of Palermo, during nearly the whole of his life. He was born at Palermo on March 17, 1814, his father being the well-known Prof. Nicolo Cacciatore, assistant at one time to Piazzi, and later his successor in the directorship of the Observatory. Gaetano Cacciatore, on the death of his father in 1841, was appointed Director of the Observatory and Professor of Astronomy in the University of Palermo, and he held these positions until 1849, when, having taken a very prominent part in the revolution of the previous year, he was compelled to leave Palermo by the return to power of the Bourbons. In 1860, however, Garibaldi recalled him to his former position. He spared no pains to increase the power and usefulness of the Observatory, and greatly increased its equipment. It was under his direction that the scope of the institution was enlarged, so that in 1880 it was reorganized in three sections—one of Geometrical Astronomy; one of Physical Astronomy, in the modern sense of the word; and the third of Meteorology.

COMET 1889 *d* (SWIFT).—A new comet was discovered on July 5·833 G.M.T., by Prof. Lewis Swift, of the Warner Observatory, Rochester, New York. The comet's place was as follows:—

R.A. = 22h. 52m. 30s. Daily Motion, − 2m.
Decl. = 89° 11′. + 10′.

COMET 1889 *b* (BARNARD, MARCH 31).—This object may soon again be observed in the early morning. The following elements and ephemeris are by Prof. Millosevich, from observations made at the Lick Observatory on March 31, April 15 and 29 (*Astr. Nach.* No. 2907):—

T = 1889 June 10·63608 Berlin M.T.

$$\left.\begin{array}{l}\pi = 186^\circ\ 38'\ 20''\cdot 8\\ \Omega = 310\ 40\ 19\cdot 3\\ \iota = 163\ 49\ 47\cdot 8\end{array}\right\}\text{ Mean Eq. 1889·0.}$$
$$\log q = 0\cdot 353613$$

Error of middle place O − C).
$\Delta\lambda = -1''\cdot 3.$ $\Delta\beta = +5''\cdot 4.$

Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
July 19 ...	5 7 52 ...	10 59·0 N....	0·3618 ...	0·4706 ...	0·83
23 ...	5 7 1 ...	10 34·4	... 0·3635 ...	0·4624 ...	0·85
27 ...	5 5 53 ..	10 7·7	... 0·3654 ...	0·4534 ...	0·88
31 ...	5 4 26 ...	9 38·7 N....	0·3675 ...	0·4436 ...	0·91

The brightness at discovery is taken as unity.

COMET 1889 *c* (BARNARD, JUNE 23).—The following elements for this comet are by Dr. H. Kreutz, from observations at Lick on June 23, at Strasburg June 25, and at Munich June 26; the ephemeris is by Prof. A. Krueger:—

T = 1889 July 2·8884 Berlin M.T.

$$\left.\begin{array}{l}\omega = 75^\circ\ 19'\cdot 5\\ \Omega = 278\ 6\cdot 7\\ \iota = 32\ 50\cdot 2\end{array}\right\}\text{ Mean Eq. 1889·0.}$$
$$\log q = 0\cdot 09248$$

Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
July 14 ...	3 1 51 ...	47 38·9 N....	0·0970 ...	0·1432 ...	0·9
18 ...	3 21 50 ...	48 35·5	... 0·1006 ...	0·1489 ...	0·9
22 ...	3 41 23 ...	49 17·9	... 0·1051 ...	0·1548 ...	0·8
26 ...	4 0 56 ...	49 47·7 N....	0·1105 ...	0·1603 ...	0·8

The brightness at discovery is taken as unity.

COMET 1888 *e* (BARNARD, SEPTEMBER 2).—The following ephemeris is in continuation of that given in NATURE for May 30, p. 109:—

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
July 11 ...	21 7 34 ...	0 1·4 N. ...	0·4287 ...	0·2491 ...	2·5
15 ...	20 52 59 ...	0 36·3 S. ...	0·4342 ...	0·2487 ...	2·4
19 ...	20 38 17 ...	1 16·7	... 0·4396 ...	0·2509 ...	2·4
23 ...	20 23 44 ...	1 58·9	... 0·4450 ...	0·2559 ...	2·3
27 ...	20 9 33 ...	2 42·0	... 0·4503 ...	0·2634 ...	2·2
31 ...	19 55 58 ...	3 25·0 S. ...	0·4556 ...	0·2733 ...	2·0

The brightness at discovery is taken as unity.

Mr. Barnard, observing this comet on June 3, at 3 a.m., noticed that it showed only one tail and that this *followed* the comet, and therefore pointed almost directly towards the sun. The tail was about a degree in length, and some 2′ or 3′ in breadth; position-angle, 90°. The head of the comet was roundish, with an almost stellar nucleus in an extended condensation, this latter having a position-angle of about 135°.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 JULY 14–20.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on July 14

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° ′
Mercury..	2 36 ...	10 37 ...	18 38 ...	6 7·1 ...	21 14 N.
Venus ...	1 10 ...	8 51 ...	16 32 ...	4 20·8 ...	18 8 N.
Mars ...	3 16 ...	11 33 ...	19 50 ...	7 3·6 ...	23 32 N.
Jupiter ...	18 38 ...	22 32 ...	2 26*...	18 4·0 ...	23 20 S.
Saturn ...	6 32 ...	14 0 ...	21 28 ...	9 30·0 ...	15 59 N.
Uranus ...	12 6 ...	17 36 ...	23 6 ...	13 7·4 ...	6 31 S.
Neptune..	0 50 ..	8 39 ...	16 28 ...	4 8·4 ...	19 20 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Sun rises, 4h. 2m.; souths, 12h. 5m. 36·0s.; daily increase of southing, 6·4s.; sets, 20h. 10m.: right asc. on meridian, 7h. 35·8m.; decl. 21° 38′ N. Sidereal Time at Sunset, 15h. 42m.

Moon (at Last Quarter on July 19, 20h.) rises, 21h. 4m.*; souths, 1h. 17m.; sets, 5h. 36m.: right asc. on meridian, 20h. 45·2m.; decl. 20° 28′ S.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.
U Cephei	0 52·5	81 17 N.	July 14,	21 5 *m*
			,, 19,	20 44 *m*
Y Virginis	12 28·2	3 49 S.	,, 18,	*M*
U Ophiuchi	17 10·9	1 20 N.	,, 18,	1 37 *m*
			,, 18,	21 45 *m*
X Sagittarii	17 40·6	27 47 S.	,, 14,	23 0 *M*
			,, 19,	2 0 *m*
Y Sagittarii	18 14·9	18 55 S.	,, 16,	22 0 *m*
U Aquilæ	19 23·4	7 16 S.	,, 17,	20 10 *m*
S Vulpeculæ	19 43·8	27 1 N.	,, 15,	*m*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near Algol	48	42 N.	Very swift; streaks.
,, γ Draconis	270	50 N.	Swift.

GEOGRAPHICAL NOTES.

THE paper read at the meeting of the Royal Geographical Society on Monday night, by Mr. Basil H. Thomson, was one of unusual scientific interest. It described a visit made by Mr. Thomson last autumn, along with the New Guinea Commissioner, to the Louisiade and D'Entrecasteaux Islands, both within the British sphere. Mr. Thomson's observations on the natives, on the geology and natural history of these islands, are of special value. The first island described is that of Sudest, the largest of the Louisiades. It is forty-five miles long and four to ten wide. It is of a slaty formation, with veins of crystalline quartz running through it in all directions. The eastern portion is mountainous, the highest point, Mount Rattlesnake, being about 3000 feet high. The highest parts are densely timbered, but the low hills near the sea are covered with grass, whose bright green offers a welcome contrast to the sombre tropical forest. Rossel Island is surrounded by a distant barrier reef of irregular form. The natives are dangerous head-hunters, who, however, kept out of the way of the visitors. With some difficulty the densely-timbered island was crossed, and proved a rich field for the botanist. Even at an elevation of 3000 feet a network of native paths was found. At the village, the inhabitants of which had fled, the party stayed the night. The village was scrupulously clean and the paths well kept. The houses were shaped like an inverted boat, built on a platform some 5 feet from the ground; the interior was reached through two trap-doors in the floor. The natives of Rossel suggest a hybrid between the Papuans and the natives of the Solomon Islands. The stone axe has fallen into disuse, its place being taken by blades of iron procured from wrecks. The language bears no resemblance to any known New Guinea dialect nor to the languages of Eastern Polynesia. St. Aignan Island, called by the natives Misima, is more than 100 square miles in area, being about twenty-eight miles long, and varying in breadth from about eight or nine miles on the east end. The west end consists of a great mountain range named Lakia, about 3500 feet above the sea, composed of schistose slate. The eastern part of the island consists of very rugged hills, through which the streams have cut very deep and narrow gorges. They are composed of coral upheaved by volcanic action, and mixed with conglomerate formed from shingle, and with broken layers of schistose slate. Round the eastern coast there is a fringe of coral, upheaved more recently, rising to a height of more than 100 feet, through which the mountain torrents have cut their way right down to sea-level. The natives are of two types, the one evidently Papuan, and the other betraying strong Malay characteristics, such as the straight hair and not prominent features. The limestone hills which compose the centre of the island were honeycombed with caves and densely timbered. From one great wall of limestone sprang a stream which, after 200 yards of daylight, plunged into a great cave in the opposite cliff. The mouth was a perfect arch, 150 feet from floor to roof. At the far end the river thundered down into a black tunnel, through which it passed under the range, emerging into daylight after some three miles of darkness. Normanby Island, the most easterly of the D'Entrecasteaux Group, is a narrow L-shaped mountain range, with deeply furrowed sides and wide valleys excavated by water-wear. It is probably nowhere of greater breadth than ten or twelve miles, and the area about 350 square miles. The highest parts of the island are perhaps 3500 feet above the sea-level. The south-eastern portion is composed of schistose slate varying much in hardness, interlaid with veins of white crystalline quartz, which is free from any compound of iron or other metal. Traces of gold were found in the creeks. Toward the north end of the island the formation is igneous, consisting mainly of limestone, but in some of the river-beds are large beds of basalt and boulders of siliceous stone. The mountains of Dawson Straits, however, differ much in formation from the rest of the island. The rock appeared to be a sort of porphyry, and furnished indications of tin. The natives have strong Papuan characteristics. They wear the usual dress. Mr. Thomson penetrated some miles inland, passing through no less than thirty-one villages, and seeing many others perched on every available spur or ridge, and surrounded by its plantations. These villages were remarkable for their cleanliness. The cultivation is wonderful, and bears witness of their activity and industry. Normanby Island is the eastern limit of the wallaby, of which were found two varieties. It is also the eastern limit of a bird peculiar to the D'Entrecasteaux Group—the largest of the five species of Manucodia, which are still classed with the birds of Paradise. It feeds on insects, and though the strait which divides Normanby Island from the mainland is only ten miles wide, this bird, which is the commonest of all large birds in the D'Entrecasteaux Group, has never crossed to New Guinea. War and the difference of dialect have so completely isolated the various tribes as to make them different peoples as regards everything but their physical characteristics. At a spot not ten miles from a tribe that would barter all they possessed for tobacco and pipes, were people so ignorant of their use that they put the tobacco into a bottle given them, poured water upon it, and drank off the compound. Ferguson Island, the largest of the D'Entrecasteaux Group, is thirty miles long by seventeen broad, with an area of about 500 square miles. There are three great mountain masses on the island: Mount Kilkerran, on the north-east corner, 6000 feet high; the Maybole Range, on the north-west, which is probably 5000 feet above sea-level; and a lower range in the south-west corner, which is apparently unnamed, and which Mr. Thomson was unable to examine. The formation of the Kilkerran and Maybole Ranges is the same, consisting principally of micaceous schist with veins of white quartz intersecting it. In the beds of the rivers were boulders of quartz, and of a slaty rock very rich in silica, and there were boulders of what seemed to be a kind of porphyry. The south-eastern part of Ferguson and the small outlying islands, Goulvain and Welle Islands, are of igneous formation, and Mr. Thomson noticed two extinct volcanoes and some hot springs. This part is densely populated, owing probably to the fertility of the extensive flats of volcanic deposit. The people were in most respects similar to those in Normanby Island. The inland or bush natives have evidently no communication with those on the coast, except as enemies: they knew nothing of firearms. They are true Papuans. At Mount Kilkerran, near Hughes Bay, it was noticed that the sides of the mountain, consisting of great precipices and steep inclines, were dotted with villages up to a height of 10,000 feet, half concealed in clumps of cocoa-nut palms. Six specimens of a variety of *Paradisea raggeana* were obtained in this island. Near Seymour Bay there was a large extent of flat land and sago swamp, in which were found some saline lakes, and some hills giving off sulphur fumes strong enough to discolour the white paint on the vessel, which was lying nearly two miles distant. Some of the hills appeared to be composed of alum and sublimed sulphur. There were also springs of boiling water and boiling mud, and in one instance boiling mud was spouted up from a chimney-like cavity in the hill-side. Goodenough Island, the most westerly of the group, was visited. A great range of mountains running north and south, and culminating in two peaks not less than 7000 feet high, forms the centre of the island. On the east side is a plain some seven or eight miles wide, nearly clear of forest. The formation is slaty schist containing much mica and quartz. On the east side are projections of igneous formation, and on the point nearest to the sulphur springs in Seymour Bay is a small crater, probably not long extinct.

OPTICAL TORQUE.[1]

II.

It will be convenient here for me to refer to some researches, not yet published, which I have made, as to the various orders of transition tints, with the view of ascertaining which of them is the most sensitive—which of them, in fact, shows the greatest change of tint for the smallest amount of rotation. Reference to the diagram on the wall displaying Newton's tints will make clear what I mean by the transition tints of the several orders. The tints obtained from quartzes of varying thicknesses may be considered as approximately identical with the tints of Newton's rings, provided we remember that the air-film which gives any particular tint in Newton's rings is about 1/300,000 part as thick as the quartz which yields the corresponding tint in the polariscope. Better far than any painted diagram, because richer and purer, are the tints now thrown upon the screen by introducing into the field a thin wedge of selenite, displaying the whole of the colours of the first three orders of Newton's scale. You will notice the successive recurrence of purple tints, both in the colours seen in the bright field, and in those seen in the dark field.

First I will show you the transition tints of the first and second orders in the bright field. That of the second order is much less intense than that of the first; and yet it is very sensitive, turning to a green tint whilst the first order purple has only turned to a blue. On the other hand, with reversed rotation of the analyzer it turns to red less rapidly than does the tint of the first order.

Next I take the transition tints of orders I., II., and III. in the dark field. These, though arranged, by means of superposed half-disks of "quarter-wave" plates, to be optically equivalent to biquartzes of two rotations, are really built up of selenite and mica. You will notice how the tint of order I. surpasses in sensitiveness both the others. I cannot here show you on the screen the means by which I have compared the tint of order I. in the dark field with that of order I. in the other set. Suffice it to say that I find the tint of order I. in the dark field—corresponding to 7·5 millimetres thickness—more sensitive than that of order I. in the bright field, which corresponds to 3·75 millimetres thickness.

A method which was at one time supposed to be more precise, was that of placing a spectroscope (or its prism) in front of the

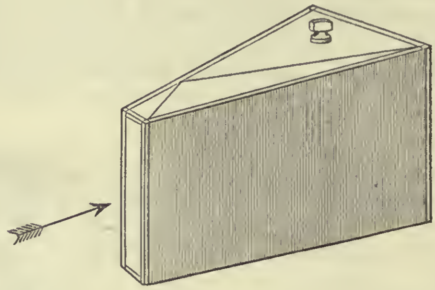


Fig. 9.—Direct-vision prism for projection of spectrum.

analyzer, and watching the motion along the spectrum of the interference bands which are then seen. My three pieces of crystal remain. I introduce a slit in front of them, also a single film of quarter-wave mica, and then a prism to give the spectrum. This prism (Fig. 9), by the way, is a new sort of direct-vision prism, having a single very wide-angled prism of Jena glass inclosed in a cell with parallel ends containing cinnamic ether (first recommended by Wernicke), a liquid which has the same

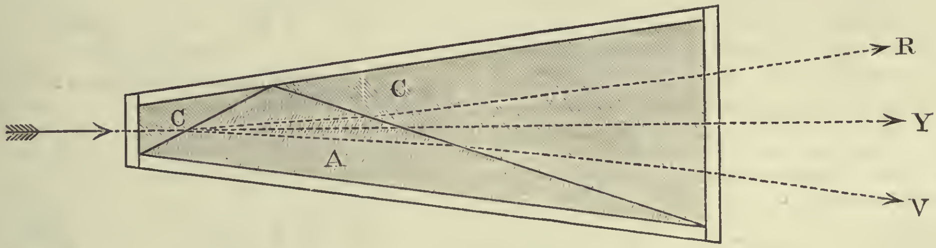


Fig. 10.—Direct-vision prism. A, wide-angled prism of Jena glass; C, cinnamic ether.

mean refractive power, but widely different dispersion. It is preferable to bisulphide of carbon in several respects: first, its odour is a delicate reminiscence of cinnamon; it is barely volatile; and it is whiter than bisulphide. This prism, which is shown also in plan in Fig. 10, was constructed for me by Messrs. R. and J. Beck. It will be seen that the dark bands in the spectrum are nebulous and ill-defined. It is idle to hope to secure accuracy by turning the analyzer until they shift along to a definite point. And there is no advantage in using the higher orders of tints which give more bands; for, though the bands are certainly better defined, their progression across the spectrum for a given amount of rotation is proportionally smaller.

Another suggestion, due to Sénarmont, is to use two sets of superposed wedges of right- and left-handed quartz. Such you now see before you. Instead of starting with extinction you start with coincidence between the upper and lower set of bands. Any rotation of the light shifts the bands, one set moving to left, the other to right. By turning the analyzer through an equal angle coincidence is again obtained.

Another method, used by Wild in his polaristrobometer, is to produce the phenomenon known as Savart's bands (due to the introduction of two crossed slices of quartz cut at a particular angle). The bands disappear when the analyzer is set in a particular direction. Anything that twists the plane of polarization causes them to reappear; but they again fade out when the analyzer is turned through an equal angle.

There is yet another method in polarimetry, due to Soleil, in which the optical torsion due to the sugar is counterbalanced or compensated by introducing a pair of sliding wedges of quartz of the opposite rotation. This device is known as a "compensator." By sliding the quartzes over one another a greater or less thickness of quartz is introduced at will. But I must not stop to illustrate this elegant device.

Yet one other method must be mentioned, and this is certainly the most preferable. It consists in aiding the eye to recognize with precision a particular degree of extinction, by the device, first suggested in 1856 by Pohl, of covering a portion of the visible field with something which slightly alters the initial plane of polarization, so that complete blackness is not obtained at once over both parts of the field. A common device is to cover half the field with a slice of some thin crystal—mica or quartz—so that only one half can be perfectly black at any instant. As an example, here is the field covered half over with a plate of mica of the thickness known as half-wave. The result is that when one half of the field is black the other is light. Adjust the analyzer now to equality. Now introduce something that rotates the light—say a tube with sugar solution in it. At once the balance is upset, and I must, in order to get equality, turn my analyzer.

Of the same class are the polarimeters with special prisms made in two parts slightly inclined to one another. The earliest of these was devised by the late Prof. Jellett, of Dublin, and has been followed by imitations of the same plan by Cornu, by Lippich, and by Schmidt and Haensch. The beautiful "shadow polarimeter," by the latter firm, which I here exhibit, has the divided prism, and a quartz compensator.

I have suggested two simpler methods of accomplishing the same end. In the first place, I have proposed to use *twin-prisms*. These are made on a plan suggested to me by finding that Mr. Ahrens's method of cutting calc-spar for prisms was admirably

[1] A Discourse delivered at the Royal Institution, May 17, 1889, by Prof. Silvanus P. Thompson. Continued from p. 235.

adapted for making such prisms, either with wide or narrow angles between the respective planes of polarization in the two parts of the visible field. Two such twin-prisms, one with 90°, the other with $2\frac{1}{2}$°, between the prisms, are here on the table. In the second place, I have essayed a polarimeter, an example of which is before you, in which an arrangement of twin-mirrors (each set at the polarizing angle, but slightly inclined to one another) is made to yield a half-shadow effect.

Before I leave the subject of quartz I must refer to the famous mathematical theory of Fresnel, who endeavoured to explain its action upon light by supposing that the plane-polarized wave on entering it is split into two waves, consisting of oppositely circularly-polarized light, which traverse the crystal with different speeds. On emerging they recombine to form plane-polarized light, the plane of which, however, depends on the

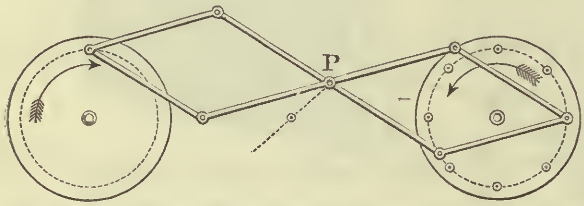


FIG. 11.—Model illustrating recomposition of rectilinear motion from two opposite circular motions.

retardation of phase between the two components. I here introduce a mechanical model to illustrate one of the points in this theory—namely, the recombination of two circular motions to form a straight-line motion. These two disks (Fig. 11), which turn in opposite senses, but at equal rates, represent two circularly-polarized beams of light. The linkages, which connect two pins on these disks, compound their motions at the central point, P, which executes, as you see, a straight line. But now, suppose one of these circular motions to be retarded behind the other, an effect which I can imitate by shifting one of the pins to another position on the disk. Still the resultant motion is a straight line, but it is now executed in a direction oblique to the former. In other words, its plane has been rotated. Of course this model must not be taken as establishing the truth of Fresnel's ingenious theory: it is at best a rough kinematical representation of it.

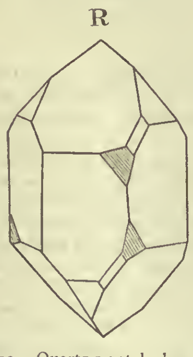


FIG. 12.—Quartz crystal, showing characteristic facets: right-handed.

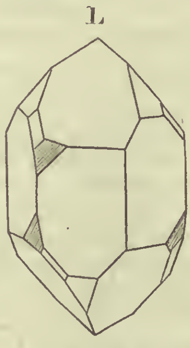


FIG. 13.—Quartz crystal, showing characteristic facets: left-handed.

We have, however, the puzzling fact still to account for that there should be two kinds of quartz crystals, right- and left-handed. Sir John Herschel first showed that natural crystals of quartz themselves often indicated their optical nature, by the presence of certain little secondary faces or facets which lay obliquely across the corners of the primary faces. These are indicated in the diagrams (Figs. 12 and 13), and may be seen in two of the specimens of quartz crystals which lie upon the table. The largest of these is right-handed. The wider generalizations of Pasteur, respecting the crystalline form of optically active substances, show that those substances which exercise an optical torque, whether as crystals or in solution, belong to the class of forms which the crystallographer distinguishes as possessing non-superposable hemihedry. In other words, they all show *skew symmetry*, as if in the growth of them they had been built up in some screw-fashion around an axis, and must therefore be either right-handed or left-handed screws. By piling up a number of wooden slabs in skew-symmetric fashion, I am able roughly to illustrate (Figs. 14 and 15) the difference between the right-handed and the left-handed structure. It is a curious fact, if I am rightly informed, that down to the present date the only substances possessing this skew symmetry are natural substances; that those which the chemist can produce by artificial synthesis are all optically inactive. It is perhaps equally significant that as yet no inorganic substances have been found which will in the liquid state rotate the light. This appears to be a property possessed solely by certain compounds of carbon. Quartz fused in the blowpipe or dissolved in potash shows no trace of rotatory power.

Yet we can have little doubt that this property is bound up in the yet unravelled facts of atomic and molecular structure. In the case of the liquids, such as turpentine and sugar solution, there must be some skew symmetry in the grouping of atoms in the molecule to produce the result. In the case of quartz, there must be a skew in the building of the molecules—there must, to borrow a phrase from the architect, be

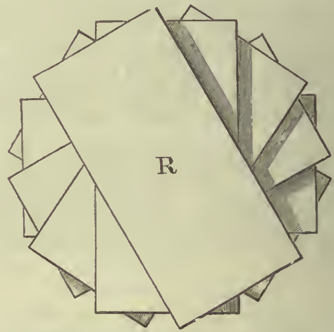


FIG. 14.—Skew-symmetrical arrangement: right-handed.

FIG. 15.—Skew-symmetrical arrangement: left-handed.

an oblique *bonding* of the minute bricks of which its transparent mass is builded. Though we cannot even rebuild it from its solution, we know this must be so, for we can reproduce all the optical phenomena which it exhibits by an actual skew building of thin slices of another non-rotatory crystal. Here is an artificial object (I built it myself) constructed on Reusch's plan, from sixteen thin slips of mica built up in staircase fashion—right-handedly—one above the other, and set symmetrically at equal angles of 45° to one another, the whole set making a cork-screw of two complete turns. In the lantern it behaves just as a quartz of about 9 millimetres thickness would do. It even gives tolerably perfect rings, as quartz does, when viewed by convergent light.

I must now pass hastily onwards to the great discovery of Faraday. Here (Fig. 16) is a magnetizing coil of wire, M, having about 8300 turns, and enclosed in an iron jacket. When it is traversed by a powerful electric current from the dynamo machine, it produces an intense magnetic field along its axis. In this axial position lies a bar of heavy glass, not quite so dense as that which Faraday himself used, but nearly so. The bar lies along the line of light from our lantern, but the polarizer, P (the Ahrens reflector, Fig. 7), and analyzer, A (the Ahrens triple spar prism, Fig. 6), are crossed, so that here is the dark field. On turning on the current, light is at once restored, being twisted to the right when the current circulates right-handedly. To measure the rotation, I must turn the analyzer; and now I find that, owing to the greater rotation of blue waves than of red, complete extinction does not occur. Introducing a half-shadow plate, and using coloured glasses, it is very easy to verify the greater amount of rotation for blue light, and to show that reversing the current reverses the rotation. You will perhaps better understand it if I use (as in Fig. 16) the 24-ray star, S, which I have previously employed. It is now obvious to you that there is a large rotation—over 50° in fact—which is reversed when I reverse the magnetizing current. We have thus repeated the fundamental experiment of magneto-optics. But now we meet with another consideration. Reflect that the circulation of current, if it be taken as right-handed when regarded from one end of the coil, will be left-handed when regarded from the other end of the coil. This is, therefore, no case of skew symmetry: it clearly indicates that something is going on in the glass which tends to twist the light quite irrespective of which way the light enters.

The next magneto-optic phenomenon is that discovered by Dr. Kerr, of the rotation of the plane of polarization by reflection at the surface of a magnet. To observe this at all requires good apparatus and a keen eye. So far as I am aware, it has never been projected on the screen. If I can succeed in doing so, it will only be because I have special means of the most

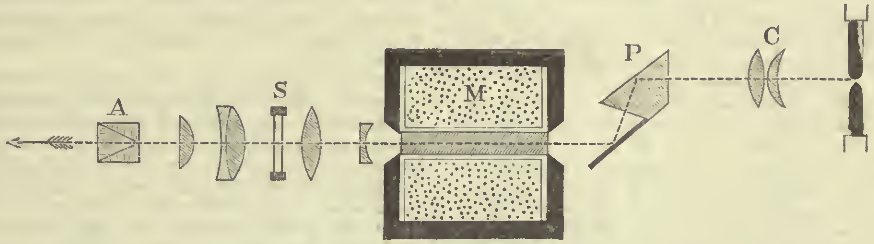


FIG. 16.—Projection of magnetic rotation of plane of polarization. C, condensing lenses; P, reflecting polarizer; M, magnetizing coil surrounding bar of heavy-glass; S, mica disk of twenty-four rays; A, analyzer (Ahrens's triple prism).

favourable character for so doing. We withdraw the bar of heavy glass from the coil, and replace it (Fig. 17) by an iron core polished at its coned end. This will be intensely magnetized when the current is turned on.

Now we must throw the beam of light obliquely down the hollow of the coil, polarizing it by one of my improved Nicol prisms, P, as it goes down. After reflection it is focussed by a lens which sends it through the analyzing prism, A. You see the dim spot of reflected light upon the screen. Now for the current: "on," "off," "on," "off." Reversing its direction ought to double the amount of torsion.

Whilst Mr. Thomas is making the needful arrangements for the next experiment, I may mention that it was found by Kerr that the effect was approximately proportional to the magnetic induction through the iron. I have myself tried some further experiments: for example, using a bar of lodestone instead of an iron core. The light reflected from lodestone is also twisted. I

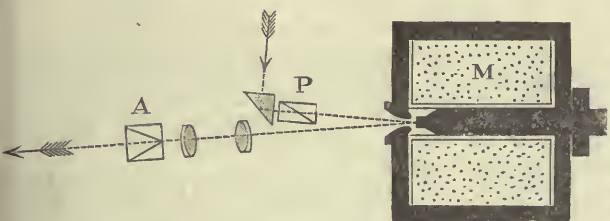


FIG. 17.—Apparatus for projecting rotation of plane of polarization by reflection at pole of magnet. P, polarizer; M, magnetizing coil with coned iron core; A, analyzer.

should expect the ferro aluminium alloy which Sir H. Roscoe showed us a fortnight ago to do the same thing, because that alloy is, as I have found, susceptible of magnetization. But I should not expect manganese steel to rotate the light, because of its singularly non-magnetizable nature.

The experiment of Kundt, transmitting polarized light through a thin transparent film of iron, magnetized normally whilst the light is passing through it, is another difficult of repetition before an audience. The small disks here are covered with films of iron, kindly prepared for me by Mr. Crookes, by squirting them electrically in a high vacuum. But the thin ones barely transmit enough light to make the observation of the effect possible even to the solitary observer. I have observed the effect projected on the screen, using this very coil and these transparent mirrors. It requires, however, an absolutely dark room, and is at best so faint that it would be hopeless to attempt to show it to a large audience. Prof. Kundt has not only observed similar rotations in other magnetic films of nickel and cobalt, but has even shown that the degree of rotation of the light is proportional not to the magnetizing force, but to the resulting magnetic induction. This is a result of utmost importance in considering the theory of the phenomenon. He has further shown that, whereas the magnetic rotations in elementary bodies, whether magnetic or diamagnetic, are in the same sense as that in which the current circulates, the magnetic rotations in compound magnetic bodies, such as a solution of sulphate of iron in water, are in the opposite sense.

These experiments with transparent mirrors of iron raise interesting speculations as to the probable nature of a transparent magnet, if such there could be. It is one of the cardinal points of Maxwell's celebrated electro-magnetic theory of light, that the better a body conducts electric currents, the greater is its tendency to absorb light and become opaque. Now, suppose it were possible to obtain a substance such as to possess greater electric conductivity in one direction than in another, such a substance ought to absorb those vibrations of light which are executed in the direction of the greater electric conductivity more than those in the direction at right angles. In other words, such a substance ought, like the tourmaline, to polarize light by absorption. Now, since the researches of Sir W. Thomson in 1856, we have known that the electric conductivity of iron is altered in the direction of the magnetic lines of force, when it is powerfully magnetized. More recently it has been discovered—I myself observed it in tinfoil, and announced the discovery to the Physical Society a few days before the announcement of the same fact by Righi—that non-magnetic metals alter their resistance in the magnetic field. Notably so do bismuth and tellurium. I had therefore conceived it possible that a film of iron or possibly of tellurium, if strongly magnetized in its own plane, might exhibit polar absorption and act like a tourmaline. Unfortunately, if the effect exists it is so faint as to be yet undiscovered, though I have made many efforts to find such. I have further tried to obtain a similar result by making a transparent magnet out of a film of magnetic oxide of iron, precipitated chemically. In this too I have not succeeded. I have tried to precipitate a transparent film of magnetic oxide in the midst of a transparent jelly. And I have mixed particles of precipitated oxide with melted gelatine so as to get a film. In this way I hoped to get, by placing the preparation in a strong magnetic field, a sort of magnetic structure which would operate upon waves of light. That such a task was not hopeless was shown by two facts: first, that many mere vegetable and animal structures can act as polarizers; and second, that a mere film of paint, such as indigo, can, if a proper mechanical drug is given to it so as to produce structure, also act as a polarizer.

The film of indigo-carmine which I have here, acts nearly as strongly, though not quite as evenly, as a tourmaline slice, and costs but a fraction of a penny.

Well, my films of jelly enclosing particles of magnetic oxide of iron do faintly act on polarized light; but their action is not as marked as that of films of jelly inclosing actual small scraps of iron. This film, when placed across the poles of this electro-magnet, between two Nicol prisms at 45°, shows an action when the magnet is turned on, as you see by the way in which it flashes into light in the dark field. When the jelly is fresh, and of the proper consistency, the action is very strong, but with the rather dry sample before you I fear we can only call the effect a *succès d'estime*.

Incidentally, in the course of these experiments on magnetic films, I came across a new magnetic body unknown hitherto, I believe, to the chemist—namely, a magnetic double oxide of cobalt and iron—a ferroso-cobaltic oxide, I think—a black powder, a sample of which I have here.

It also occurred to me, as a matter of speculation, that if I could strongly magnetize a crystal of ferrous sulphate or nickelous sulphate, whilst viewing it by convergent polarized light I might find some interesting phenomena, which should, if they existed, show some sort of a relation between the direction of the optic axis and that of the lines of the magnetic field. I thought that a longitudinal magnetization might possibly set up a rotatory phenomenon like that in quartz in so far as to disturb the central field between the arms of the black cross; however, not by the most powerful magnetizing could I discover any such effect. Again, I thought that by magnetizing transversely to the optic axis I might possibly succeed in turning the uniaxial crystal into a biaxial, or producing by magnetism an effect resembling the action of heat on crystals of selenite. Owing probably to the small depth of any crystals that can be obtained, I have failed so far to obtain any such effect, though I am convinced that it must exist.

An effect precisely analogous to the magnetic effect which I vainly sought has, however, been lately discovered by Prof.

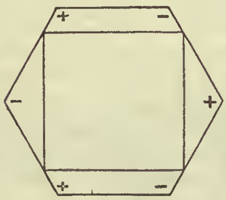


Fig. 18.

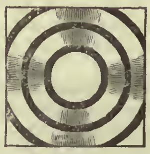


Fig. 19.

Röntgen. I sought a distortion of the optic axis by transversely magnetizing, and I sought it in crystals of sulphate of nickel: he has found a distortion of the optic axis by transversely electrifying, and he has found it in crystals of quartz.

Suppose a piece of a quartz crystal is cut as a square prism, its long faces being principal planes of section respectively parallel to and at right angles to two of the natural faces of the hexagonal prism. Fig. 18 shows the form of the portion cut. The + and − signs in this figure refer to the pyro-electric poles of the crystal. Such a piece viewed by convergent light shows the usual rings and black cross with a coloured centre (Fig. 19). If now two opposite faces be covered with tinfoil, and the crystal be electrified transversely, the rings are distorted into lemniscates, the direction of the distortion changing with the sign of the electrification. It is necessary to use a red glass, or still better sodium light, to observe the changes in form on reversing the sign of the charges. Figs. 20 and 21, 22 and 23, show the changes of form, but these sketches grossly exaggerate the effects. As you see upon the screen, when the charges imparted by this fine Wimshurst machine are rapidly reversed, there is a decided distortion of the rings, but it is small in amount.

Returning to the phenomena of the rotation impressed by magnetism on polarized light, I may point out that the torque which a magnetic field exerts on the light-waves appears to be really an action upon the matter through which the light-waves are passing. It is as though the magnetic field were really a portion of space rotating rapidly on itself, or perhaps as though the ether were there rotating, and that this rotation in some way dragged the particles of matter along with it. It has long been supposed necessary, in order to account for the refractive and dispersive properties of transparent bodies, to consider that their particles are in some way concerned in and partake of the vibrations going on in the ether within them or between their molecules. It is impossible to explain the phenomena of magneto-optic rotation by the supposition that any skew structure is imparted to the medium; for these phenomena, unlike those of quartz, do not exhibit skew symmetry. There seems to be no other way of explaining the magneto-optic torsion of light than by supposing that the molecules of matter in the magnetic field are actually subjected to rotatory actions; as indeed was suggested long ago by Sir William Thomson.

However, there is room here not only for speculation but for experiment. Some day, when facts enough have been collected, we shall be ready to build thereon the wider generalization which at present seems to escape us.

So far we have been applying an optical torque to previously polarized light, and producing a torsion of it. It remains for me yet to describe the means by which, in the hands of Prof. Abbe and Prof. Sohncke, it has been demonstrated that natural, non-polarized light is actually rotated when subjected to an optical torque.

The way of doing this is to make use of the principle of interference. Here is a slit from which a narrow beam of light-waves issues. At a point a little distance away is a Fresnel's biprism which splits up the light (without polarizing it) into two beams, just as if we had two slits or sources of light. These two beams pass along, and meet upon this distant screen, and give us—what? A set of interference fringes, having a bright line down the middle, because this part of the screen is exactly equidistant from the two sources of light.

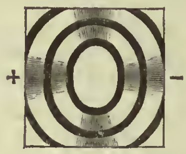


Fig. 20.

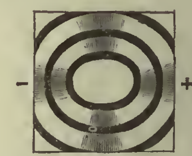


Fig. 21.

Fig. 22.

Fig. 23.

But these dark interference fringes that lie right and left can only exist because, in the first place, the vibrations have travelled unequal paths differing by an odd number of half wave-lengths; and secondly, because (owing to the method adopted of using two images of one slit) the phases of the emitted waves from the two sources are identical.

This being so, let us now introduce across the two interfering beams of light a special biquartz, made of right- and left-handed quartz of only 1·88 mm. thick. This will rotate—*if it rotates natural light at all*—the yellow light in one beam 45° to the right and that of the other beam 45° to the left. The angles will be a little more for green and blue, a little less for red and orange. Consequently we shall not get quite a perfect result for all kinds of colours. But for the main body of the light the result is this: that because the two beams have had their respective vibrations turned so that, whatever their primitive positions, they are now at right angles to one another, they cannot interfere. In other words, if it be true that the quartz rotates natural light, the interference bands will die out. [Experiment shown.]

Here I have the light passing through the biprism only, and giving us this narrow series of interference bands. You must notice carefully—with opera-glasses if you have them—the narrow bright and dark stripes. Now I shift this little diaphragm so that the light passes through the biquartz as well. Instead of sharp interference bands we have merely a dull line of nebulous light. The disappearance of the fringes proves that quartz does twist the not-previously-polarized waves of light.

That the magnetic field can also exert a magnetic torque on non-polarized light is readily proved, at least when one already has the biquartz. Two strips of heavy-glass of exactly equal length and similar quality, such as those I hold in my hand, must be introduced in the respective paths of the two beams: and one at least of them must be surrounded by a magnetizing coil. The biquartz has wiped out the interference fringes; but on magnetizing one of the two pieces of heavy-glass, or on magnetizing the two in opposite senses, the interference bands can be made to reappear. It is in this way that Prof. Sohncke's experiment—hardly suitable for a lecture theatre—was performed. It is in this way that we establish upon an experimental basis the fact that light itself, and not merely the plane of its polarization, experiences an optical torsion when subjected to those forces which, whether crystalline, molecular, or magnetic, exert upon it an optical torque.

BABYLONIAN ASTRONOMY.[1]

II.

THE year—that is, the period bringing back the recurrence of the seasons—is not a primitive means of dividing time, but the result of many observations. The simplest way of marking time is by seasons, and the system is still employed by some savage nations in Africa. A season does not correspond to one year, and more than one may be in a year; seasons, however, generally correspond to the year period. As to the division of the year, it must have varied according to the climate and region, but the simplest is by ten, as ten is the most common dividing number, and such was the one originally adopted by the Semites and Egyptians. This year of ten months, or rather ten parts, has left traces among the Semites and in classical authors. The Babylonians assimilated their first ten kings to the ten parts of the year. At Rome, we are told that the year before Numa Pompilius was composed of ten months only.

A year of ten lunar months is impossible, for after two or three of such periods it would no longer correspond with the seasons. We find, therefore, that the ten parts of the year were composed of thirty-six days distributed in four periods or weeks of nine days. This last division was not, however, official: the days of each of the ten divisions of the year were merely numbered from one to thirty-six; it was at a later date that the days received names from the protecting gods attributed to them.

It is to be noticed that in Egypt the months had no special names; the year was divided, after the reform of the calendar, into three seasons of four months of thirty days, called first, second, and so on, of the season to which they belonged. Popular names were attributed to them afterwards, taken from the religious festivals, but they do not appear in the texts before the Ptolemaic period. The like took place among the Semites: the months were called first, second, third, and so on, but were not distributed into seasons. It was only after the Akkadian invasion that the other names, Nisan, Tyyar, &c., were adopted, and the eighth month never lost its numerical name. In the astronomical omen tablets the primitive nomenclature by numerical order was often preserved.

It is still uncertain at what time the old calendar of ten divisions of thirty-six days was reformed into one of twelve months of thirty days. The change was due to the desire to measure the time by the appearance of the moon. This reform may be due to the influence of the Akkadians, who made the conquest of Babylon about 7000 B.C. These people had a lunar calendar composed of thirteen months of twenty-eight days, giving, therefore, a year of 364 days. It was no doubt more accurate than the Semitic calendar, but the Akkadians adopted their subjects' calendar. The deficiency with the normal solar year of 365 days was made up by means of a supplementary month placed irregularly by the priests when they thought it necessary. That is why we find various intercalary months, and why, in some cases, as late even as Nebuchadnezzar the Great, they occur in three successive years. To make up the deficiency the Babylonians had also a supplementary day called the "heavy 21st," which could be inserted in any month before the normal 21st. We find the mention of such supplementary days in several consecutive months.

The Akkadians, before invading Babylonia, divided their month into four parts or weeks of seven days each. This division had, however, nothing to do at first with the planets, to which the days were assimilated only at a later date. The Akkadians looked on the planets as evil spirits disturbing by their irregular motion the harmony of heaven; and, as evil spirits were the chief objects of their worship, they naturally attributed to each day of the week the name of a planet. When the Akkadians adopted the Semitic month of thirty days, the week of seven days was naturally abandoned in common use, but it was retained for religious purposes with some modification, a new series of four weeks commencing with each month. The Semites rejected the Akkadian names of the days of the week, though they preserved the symbolism attached to them, as is shown by the seven tablets buried under the foundation-stone of Khorsabad.

Our names of the days of the week are derived from the Akkadian assimilation of these days to the planets. There is no doubt as to the order in which the planets were assimilated to the names of the days, if we compare them with the colours of the walls of Ekbatana built by a Medic tribe, which preserved the primitive religion of the Akkadians, and also with the tablets of Khorsabad. The following table will show the correspondence:—

Names of the days and planets.	Colours of the walls of Ekbatana.	Materials of the tablets of Khorsabad.
1 Sunday (the Sun)...	Gold	Gold
2 Monday (the Moon)	Silver	Silver
3 Tuesday (Mars) ...	Orange	Copper
4 Wednesday (Mercury)	Blue	Tin
5 Thursday (Jupiter)	Red	Iron
6 Friday (Venus) ...	Black	Basalt
7 Saturday (Saturn)...	White	Limestone

Iron, corresponding to Thursday, or Jupiter, is represented by a red colour, no doubt on account of the rust, which is red. And we must not be surprised to see Venus represented symbolically by black, for Vesper or the Evening Star is really the *dusky*.

This proves that the week of seven days, which is found all over Asia and Europe, spread, not from Babylonia, but from the country whence came the Akkadians.

[1] Abstract of the second lecture delivered by Mr. G. Bertin at the British Museum. Continued from p. 237.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of this Institution was held in Paris last week under the presidency of Mr. Charles Cochrane.

The papers offered for reading and discussion were a description of the lifts in the Eiffel Tower, by Mr. A. Ansaloni, of Paris, supplemented by the results of working to date, communicated verbally by Mr. Gustave Eiffel, President of the Société des Ingénieurs Civils; the rationalization of Regnault's experiments on steam, by Mr. J. Macfarlane Gray; on warp-weaving and knitting without weft, by Mr. Arthur Paget; on gas-engines, with description of the Simplex engine, by Mr. E. Delamare-Deboutteville; on the compounding of locomotives burning petroleum refuse in Russia, by Mr. T. Urquhart; and description of a machine for making paper bags, by Mr. Job Duerden.

In the discussion of the first paper, which, as its title shows, was mainly technical in character, the interesting meteorological circumstance of the Eiffel Tower acting as a thunder-cloud discharger was referred to; clouds laden with electricity having passed quietly over the region of the tower, which previously and afterwards flashed with lightning. It was also pointed out that the perpendicularity of the building is not affected by temperature variations, nor by any wind pressure hitherto recorded.

We have not received a copy of the paper by Mr. Gray, who reserves the right of reproducing it, but from the syllabus of papers published by the Institution of Mechanical Engineers, it may be stated that Mr. Gray proposes a new unit of heat, which he compares with the ordinary water-unit, and a new diagram of energy, which he calls the Theta-phi ($\theta\ \phi$) or temperature-entropy diagram, a graphic representation of the Carnot-Clausius fundamental principle, of which the area shows heat-units, the co-ordinates being the temperature, θ, and entropy, ϕ. He compares Regnault's experimental steam-pressures with the pressures calculated by means of his formulæ, showing closer agreement than is obtained by Regnault's most accurate formulæ.

In Mr. Paget's paper the three chief methods of making fabric or cloth or tissue from yarns or threads, viz. ordinary weaving, knitting, and what the author calls warp-weaving, are referred to. The paper describes the method by which shaped goods can be made by warp-weaving, and the machine by which this is effected. The machine, which is of a very ingenious character, comprising several interesting points of construction and detail, is at work at the Paris Exhibition.

Mr. Deboutteville, in his paper, first reviews the gas-engines hitherto proposed or employed. He carries back his researches nearly a century, when the first gas-engine was proposed by Barber, and completes them with a description of the Simplex engine, which he brought out with Mr. Malandin in 1884. This engine is founded on principles laid down by Mr. Beau de Rochas—that, to realize the best results from the elastic force of gas, the cylinders should have the greatest capacity with the smallest circumferential surface, the speed should be as high as possible, the cut-off should be as early and the initial pressure as high as possible. In the author's engine the ignition is effected by a practically continuous electrical spark; the air and gas are mixed in an external receptacle fixed on the cover of the slide, and are drawn in through channels of varied forms so as intimately to mix them. The governors described act on the principle of totally cutting off the supply of gas for one or more strokes whenever an increase of speed occurs. From the tests made with this engine the consumption of gas is low, and it appears to compare favourably with good steam-engines as regards economy of application.

Besides the reading and discussion of papers, the members of the Institution visited the Exhibition, and various works which were opened for this purpose.

SCIENTIFIC SERIALS.

THE numbers of the *Journal of Botany* for June and July are chiefly devoted to articles interesting to students of systematic or geographical botany, especially that of our own islands; the latter number contains a biographical sketch of the late Prof. Reichenbach, by the editor.

THE most interesting article in the *Botanical Gazette* for May is the commencement of a detailed paper by Mr. C. Robertson, on the relations between insects and flowers in regard to American plants. The number for June contains original articles by Mr. H. L. Bolley, on sub-epidermal rusts, and by Mr. J. N. Rose, on the Achenia of *Coreopsis*.

THE *American Meteorological Journal* for May contains abstracts of the papers read at the meeting of the New England Meteorological Society on April 16:—In a paper on lightning and the electricity of the atmosphere, Mr. McAdie gave an account of some kite experiments at the Blue Hill Observatory, near Boston, in which the potential was determined at various heights. He also referred to the observations on the character of lightning at the top of Mount Washington during thunderstorms, and to the effect of the electrification of the air upon water, dust, and other particles in it, and to the possibility of foretelling the moment of a flash of lightning.—Prof. W. M. Davis made a report upon the investigation of the sea-breeze, undertaken in 1887, from observations at 100 stations. One fact shown was that the diurnal range of temperature, which is diminished on the coast by the action of the sea-breeze, is not lessened at the inland stations.—Mr. E. B. Weston read a paper on the practical value of self-recording rain-gauges, referring to the importance of knowing the hourly falls when constructing drainage systems.—Prof. H. A. Hazen continues the discussion upon anemometer comparisons, and upon the question of the probable effect of the momentum of heavy cups, when placed on a whirling machine. He considers that the Robinson anemometer is by far the best instrument ever devised for variable winds.—Lieut. Finley discusses the frequency of tornadoes in Illinois for fifty-four years, ending with 1888. The total number of storms was 141. The month of greatest frequency was May, no month being free from storms. The prevailing direction of movement was north-east.—Prof. Harrington communicates the instructions issued by the Chief Signal Officer for the preparation of forecasts and for their verification. The instructions contain nearly 200 regulations, and are very interesting to those who study weather predictions.

THE *Meteorologische Zeitschrift* (Vienna) for June contains the first part of an epitome of Dr. von Bezold's papers on the thermodynamics of the atmosphere, which have already been summarized in our notices of Societies.—Dr. J. Hann contributes a valuable article on the results of the meteorological observations of the late Prof. A. Ackermann at Port-au-Prince, Hayti, 1864–68, being a part of the world where they are of special value. The observations were rescued from entire loss by the exertions of Dr. Hann and Prof. J. Scherer, the originals having been wilfully destroyed. The distribution of rainfall is much affected by the mountain features of the island; in the north the rainy season is from December to April, while in the south it is from May to July. The average yearly rainfall at Port-au-Prince, from the above observations, was 61 inches, on 153 days. The greatest daily fall was 5·6 inches in May 1865, the rain lasting four hours. The climate is very equable; the mean of the absolute maximum temperatures was 98°·2, and of the minimum 56°·8.—Dr. von Lepel describes his experiments in passing electric sparks through glass tubes lined with a thin coating of paraffin, and containing a small amount of moisture, and points out that during thunderstorms many similar discharges may be observed, and may find their explanation in these experiments. The sparks differ in character and in colour, and the author argues that the humidity in the tube may be compared to the particles of vapour in the thunder-clouds, and that the coating of paraffin may have the same optical effect as the translucent clouds themselves. He gives the results of his thunderstorm observations on these lines during the summer of the year 1888.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, June 22.—Prof. Reinold, F.R.S., President, in the chair.—The following communications were made:—Note on some photographs of lightning, and of "black" electric sparks, by Mr. A. W. Clayden. The lightning photographs, three in number, were obtained during the storm on June 6. Two flashes, seen on one plate, show complicated and beautiful structure: one of them is a multiple flash, and flame-like appendages point upwards from every angle; the other is a broad ribbon, and, although the plate shows signs of movement, the displacement is not in a direction such as would produce a ribbon-like effect from a linear flash. The second plate shows four flashes, none of which are ribbon-like, though the camera had moved considerably. The third plate was exposed to six flashes, one of which was believed to pass down the middle of the plate; but, on development, only a triple flash in one corner of the plate was seen. Careful search, however, revealed the central flash as a dark one with a white core, and other dark flashes were subsequently found. The plate was very much over-exposed, and this suggested that black flashes might be due to a sort of cumulative action caused by the superposition of the glare from a white cloud upon the normal image of the flash. To test this, sparks from a Wimshurst machine were photographed, and, before development, the plates were exposed to diffused gas-light for a short time. The bright sparks yielded normal images with reversed margins, and the faint ones were completely reversed. Other experiments showed the reversal to spread inwards as the time of exposure to gas-light increased. Finally, reversal was effected by placing a white screen behind the spark, to represent a white cloud, the only illumination being that of the spark itself. In the discussion which followed, Mr. W. N. Shaw exhibited a photograph taken during the same storm, which is particularly rich in dark flashes branching outwards from an intensely bright one. In some places the bright line has dark edges, and in one part a thin bright line runs along the middle of an otherwise dark portion of the flash. In answer to Mr. Inwards, Mr. Shaw said the plate was exposed about half a minute, and the former thought that, under those conditions, the appearance of the plate did not contradict Mr. Clayden's hypothesis. Speaking of the same photograph, Prof. Perry considered that Mr. Clayden's observations would explain the result, for a bright flash required more exposure to diffused light to reverse it than a faint one did. Prof. Ramsay reminded the meeting that Prof. Stokes's "oxides of nitrogen" explanation was still a possible one; and Mr. C. V. Burton asked whether they may be due to faint sparks cutting off light from brightly illuminated clouds, just as a gas-flame absorbs light from a brighter source. In reply, Mr. Clayden thought the "oxides of nitrogen" hypothesis improbable, and said his experiments did not enable him to answer Mr. Burton's question. As regards Mr. Shaw's plate, he believed the diffused light from the clouds would be sufficient to reverse the fainter tributary flashes, although it was insufficient to reverse the primary one. From data obtained when the ribbon-flash was taken, he had made some calculations which gave the height of the clouds about 1000 yards, and the ribbon-flash 1300 yards long and 100 yards wide.—Researches on the electrical resistance of bismuth, by Dr. Ed. von Aubel. The paper, which is in French, was taken as read. A translation will appear in the Proceedings of the Society.—Expansion with rise of temperature of wires under pulling stress, by J. T. Bottomley, F.R.S. The investigation was to determine whether the coefficient of expansion of wires depends on the stress to which they are subjected, and was undertaken in connection with the secular experiments on the elasticity and ductility of wires, now being conducted at Glasgow University. Two wires, about 17 feet long, of the same material, were suspended side by side within a tube, through which steam could be passed to change the temperature. One wire was loaded to half, and the other to one-tenth its breaking weight, and, in the preliminary experiments the elongations were read by a Quincke's microscope cathetometer. About 150 heatings and coolings, extending over three months, were necessary to bring the heavily loaded wire to its permanent state, so that consecutive expansions and contractions were equal. When this stage was reached, hooks of peculiar shape were attached to the lower ends of the wire. These hooks form a relative geometrical guide, and their horizontal parts mutually support a small table which carries a plane mirror. If the wires expand or contract unequally, the mirror becomes tilted, and the relative displacement is observed by means of a telescope and scale fixed nearly vertically over the mirror. From experiments on copper wires, the coefficient of relative expansion was found to be 0.32×10^{-6} per degree Centigrade, or about 1/55 of the ordinary linear expansion of the material. The heavily loaded wire expanded most. The results for platinoid give 0.27×10^{-6} as the relative coefficient under the conditions named above; this is about 1/57 of the ordinary linear expansion, which, from separate experiments, was found to be 15.4×10^{-6}. Mr. H. Tomlinson thought the probationary period for copper might be considerably shortened by repeatedly putting on and taking off the load, and by subjecting the wire to torsional oscillation. With iron wires this would not be the case, for they behave in a most peculiar manner, and require long periods of rest after each oscillation. From experiments he had conducted during the last two years, he found that the permeability of iron could be enormously reduced by repeated heatings and coolings whilst undergoing magnetic cycles of small range. Mr. Gregory said the paper threw considerable light on some experiments on the sag of stretched wires upon which he was engaged. He also suggested heating the wires by electric currents. In reply, Mr. Bottomley said he had considered it important to leave the wires untouched after being suspended, and as regards heating by electricity he thought that convection-currents would make the temperature non-uniform.—Owing to the absence of Prof. S. P. Thompson, his "Notes on Geometrical Optics" were postponed.

Linnean Society, June 20.—Mr. Carruthers, F.R.S., President, in the chair.—Dr. H. Trimen exhibited specimens and drawings of the tuberculated lime of Ceylon, and made some interesting remarks thereon.—Governor Moloney, of the Colony of Lagos, West Africa, exhibited an extensive collection of butterflies and moths, the result of twelve months' collecting during the rainy season. The former, comprising representatives of 65 genera and 158 species; the latter, 78 genera and 112 species, had been named and arranged by Mr. Herbert Druce. A few Chelonians, belonging to the genera *Trinonyx*, *Sternothœrus*, and *Cinixys*, were also exhibited, and a remarkably large block of resinous gum, which, in the opinion of Prof. Oliver, was referable to some species of *Daniellia*, and which had been found in Ijo country. As an article of commerce, it possessed the advantage of requiring a heat of 600° F. to "run" it, so as to unite with linseed oil in the manufacture of varnish. In addition to these specimens, Governor Moloney exhibited some long bows and cross-bows obtained from chiefs of Ibadan from some battle-field in that neighbourhood, and used by natives 300 miles from the coast-line. A discussion followed, in which Dr. Anderson, Mr. D. Morris, and Mr. Harting took part.—Prof. Stewart next exhibited some skulls, adult and immature, of *Ornithorhynchus paradoxus*, and explained the very curious dentition of this animal; upon which Dr. Mivart and Prof. Howes made some critical remarks.—A paper was then read by Dr. John Anderson, F.R.S., on the mammals, reptiles, and Batrachians which he had collected in the Mergui Archipelago, and concerning which he had been enabled to make some interesting field-notes. Attention was particularly directed to a new bat (*Emballonura*), and to the occurrence, on some of the islands, of *Pteropus edulis*, besides a wild pig, musk deer, gray squirrel, and a crab-eating monkey (*Semnopithecus*), which hunts along the shore in search of Crustacea and Mollusca. Some remarks were made on rhinoceros going out to sea, and on a crocodile being found twenty miles off the coast.—A communication was read from Mr. Charles Packe, on a remarkable case of prolonged vitality in a fritillary bulb.—The meeting (the last of the session) was brought to a close by a most interesting demonstration on animal locomotion, by Mr. E. Muybridge, who illustrated his remarks with projections on the screen, by oxy-hydrogen light, of instantaneous photographs taken by him, to which motion was imparted by means of the zoopraxiscope.

SYDNEY.

Royal Society of New South Wales, May 1.—Annual Meeting.—Sir Alfred Roberts in the chair.—The report stated that twenty new members had been elected during the year, and the total number on the roll, April 30, was 474. During the year the Society held seven meetings, at which the following papers were read:—Presidential address, by C. S. Wilkinson.—Forest destruction in New South Wales, and its effects on the flow of water in water-courses and on the rainfall, by W. E. Abbott.—On the increasing magnitude of η Argûs; on an improvement in anemometers; on the storm of September 21, 1888; on a new self-recording thermometer; and on the thunderstorm of October 26, 1888, by H. C. Russell, F.R.S.—Notes on some minerals and mineral localities in the northern districts of New South Wales, by D. A. Porter.—On a simple plan of easing railway curves, by W. Shellshear.—On the anatomy and life-history of Mollusca peculiar to Australia; and on the desert sandstone, by the Rev. J. E. Tenison-Woods.—Description of an autographic stress-strain apparatus, by Prof. Warren.—Considerations of phytographic expressions and arrangements, by Baron Ferd. von Mueller, K.C.M.G., F.R.S.—Indigenous Australian forage plants (non-grasses), including plants injurious to stock; some New South Wales tan substances, Part 5, by J. N. Maiden.—Census of the fauna of the older Tertiary of Australia, by Prof. Ralph Tate.—Results of observations of comets I. and II., 1888, at Windsor, New South Wales, by John Tebbutt.—The Latin verb *jubere*, a linguistic study, by Dr. John Fraser.—Notes on some New South Wales minerals (Note No. 5), by Prof. Liversidge, F.R.S.—The Medical Section held seven meetings, at which the attendance was far above the average; the papers read and specimens exhibited were interesting and valuable. The Microscopical Section held seven meetings. The Clarke Medal for the year 1889 had been awarded to R. L. J. Ellery, F.R.S., Government Astronomer for Victoria. The Society's bronze medal and money prize of £25 had been awarded to the Rev. J. E. Tenison-Woods for his paper on the anatomy and life-history of Mollusca peculiar to Australia, and the Council has since issued the following list of subjects with the offer of the medal and a prize of £25 for each of the best researches if of sufficient merit:—(To be sent in not later than May 1, 1890): The influence of the Australian climate (general and local) in the development and modification of disease; On the silver ore deposits of New South Wales; On the occurrence of precious stones in New South Wales, with a description of the deposits in which they are found. (To be sent in not later than May 1, 1891): The meteorology of Australia, New Zealand, and Tasmania; Anatomy and life history of the Echidna and Platypus; The microscopic structure of Australian rocks.—The Chairman read the Presidential address, and the officers and Council were elected for the ensuing year. Prof. Liversidge, F.R.S., was elected President.

PARIS.

Academy of Sciences, July 1.—M. Des Cloizeaux, President, in the chair.—On a flow of molten glass occasioned by the accidental piercing of a glass furnace, by M. F. Fouqué. An account is given of the sudden escape of about 400,000 kilogrammes of molten glass from the Clichy-la-Garenne Works, and a comparison is drawn between the action of the discharge and that of volcanic lavas. The absence of bubbles near the surface of the former, and the other differences noticed between the two streams, are attributed mainly to the different chemical composition of the initial magma of each substance. The wollastonite peculiar to the vitreous flow solidifies under very different conditions from those of the feldspars and ferro-magnesian bisilicates occurring in the molten lavas.—The thermo-chemical compared with the surgical method in the study of the animal organism, by M. Sappey. In continuation of his recent communication on this subject, the author here contrasts the advantages and defects of the old and new processes, showing how they are complementary one of the other, and should consequently be associated in all important anatomical researches.—On the duration of lightning, by M. Daniel Colladon. In connection with M. Trouvelot's recent note, the author claims priority of discovery, having shown nine years ago that in thunderstorms the flash cannot always be instantaneous, and must last perceptibly longer than the thousandth part of a second assigned to it by Wheatstone.—Presentation of a volume of the "Annales de l'Observatoire de Paris: Observations de 1883," by M. Mouchez. The delay in issuing this volume is mainly due to the greatly increased number of meridian observations which were required to complete the revision of Lalande's Catalogue. The volume for 1884 is already half printed.—Note accompanying the presentation of M. Ch. Ed. Guillaume's work entitled "Traité Pratique de la Thermométrie de Précision," by M. Cornu. In this work is embodied a summary account of the researches that have been undertaken by the International Bureau of Weights and Measures for the purpose of removing the defects in the mercury thermometer, and giving the required degree of accuracy to that instrument.—On a new apparatus for zoological and biological research at determined marine depths, by Prince Albert of Monaco. With a view to remedying the defects of the instruments used in the expeditions of the *Challenger*, the *Blake*, and the *Vettor Pisani*, the author has prepared the instrument here described and illustrated. It is constructed on entirely new principles, and may be let down closed to any desired depth, then opened for purposes of observation, and re-closed before being brought to the surface. With this appliance Prince Albert has operated with satisfactory results to a depth of 500 metres in the Madeira waters.—Influence of temperature on the mechanical properties of metals, by M. André Le Chatelier. The mechanical properties of the metals at the different temperatures to which they are exposed in the various industrial processes have hitherto been little studied. The author here describes a series of researches that he has undertaken chiefly for iron and steel, but also for copper, zinc, aluminium, silver, nickel, and sundry alloys of copper, iron, and nickel. The results of these researches show generally that the mechanical properties of these metals are gradually modified with increased temperature. The detailed results obtained for iron and steel are reserved for a future communication.—On the malonates of barium, by M. Massol. The neutral malonates $CH_2(COO)_2Ba \cdot 2H_2O$ and H_2O, with their respective heats of solution and heats of formation, are described.—On the sardine fisheries on the coast of Brittany in 1888, by M. Georges Pouchet. The shoals were fully as abundant as in 1887; but for some unexplained reason there was a total suspension of the fisheries from about June 28 to July 20, during which period the sardines everywhere disappeared from the seaboard.—On the scales and calcareous epidermic glands of Globularia and Selago, by M. Edouard Heckel. During his general anatomical researches undertaken to establish a histotaxic classification of the Globularieæ, the author has detected in some species certain prominent anatomical characters, which appear to have escaped the notice of the numerous botanists who have occupied themselves with this family. They are described as calcareous epidermic glands of a scaly type, and are regarded by M. Heckel as condensed hairs clothing the outer surface with granular and crystalline calcareous concretions, instead of secreting an internal cystolith and localizing it in their unicellular chamber, as is the case with the Urticeæ, Verbenaceæ, and some other families.—On the occurrence of a granulite with riebeckite characters in Corsica, by M. Urbain Le Verrier. A microscopic study of this rock, which occurs in large masses about the middle of the west coast, shows that it is a hornblende of a special type, presenting the characters of the riebeckite recently described by M. Sauer.—On the leaves of Lepidodendron, by M. B. Renault. Since his last communication on this subject (*Comptes rendus*, November 28, 1887), the author has found a considerable number of leaves of Lepidodendron in the fossiliferous quartzes of Combres, de Lay, and Esnost near Autun. Some were still attached to the branches of *L. rhodumnense* and *L. esnostense*, and the present paper is restricted to a description of the former species.—The Quaternary stations in the neighbourhood of Lorrez-le-Bocage, Seine-et-Marne, by M. Armand Viré. In these stations, numbering about ten, and distant 25 leagues from Paris, M. Viré has collected several thousand flint instruments and weapons of different types, besides a few fragments of a blackish unornamented pottery.

Stockholm.

Royal Academy of Sciences, June 5.—On the heredity of exterior lesions and of acquired characters, by Prof. G. Retzius.—Prof. A. F. Smitt reported upon a paper, by Dr. Fr. Heincke, of Oldenburg, entitled "Researches on the Stickleback."—Baron Nordenskiöld exhibited some fine specimens of minerals from Norway, sent as a gift by Dr. Jellef Dahl.—Prof. Nilson reported upon an investigation by himself and Prof. O. Pettersson on the molecular weight of chlor-aluminium. They have found that it is expressed by the formula $AlCl_3$ and not by Al_2Cl_6, as given by Friedel and Craft.—On some definite integrals, by Dr. Lindman.—Observations on the tidal waters at Polhun in Spitzbergen, by Prof. Wijkander.—On the ammoniacal combinations of iridium, by Herr W. Palmar.—On amidoximes and azoximes within the triazol and tetrazol series, by Dr. Bladin.—On the action of cyanium on *a*- and *b*-naphthylamin, by Herr O. Nordenskiöld.—On *a*- and *b*-monofluornaphthalin, by Messrs. A. Ekbom and R. Manselius.—Observations on the radiation of the sun, by Dr. K. Ångström.—Ornithological observations made during the year 1887 at Sandhamn and its neighbourhood, by Herr O. Ekbohm.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Proceedings of the Society for Psychical Research, June (Trübner).—Proceedings of the Geologists' Association, November 1888 (Stanford).—Journal of the Royal Microscopical Society, June (Williams and Norgate).—Bulletin of the U.S. Geological Survey, No. 43 (Washington).—The Geological and Natural History Survey of Minnesota, Report for the Year 1887 (St. Paul).—Aus dem Archiv der Deutschen Seewarte, ix. Jahrg., 1886; x. Jahrg., 1887 (Hamburg).—Musical Instruments and their Homes; M. E. Brown and W. A. Brown (New York, Dodd).—The Second Report upon the Fauna of Liverpool Bay and the Neighbouring Seas: edited by Prof. Herdman (Liverpool).—The Chemistry of the Coal-tar Colours, 2nd edition: Dr. R. Benedikt; translated and edited by Dr. E. Knecht (Bell).—Contributions to the Tertiary Flora of Australia: Dr. Constantin (Sydney, Potter).—Hydraulic Motors: G. R. Bodmer (Whittaker).—Contributions to the Knowledge of Rhabdopleura and Amphioxus: E. Ray Lankester (Churchill).—Der Einfluss einer Schneedecke auf Boden. Klima und Wetter: A. Woeikof (Wien).—The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales: R. Etheridge, Jun. (Sydney, Potter).—Proceedings of the Geologists' Association, May (Stanford).—Mind, July (Williams and Norgate).

CONTENTS.

THURSDAY, JULY 18, 1889.

THE PROPOSALS OF THE COMMISSIONERS FOR THE EXHIBITION OF 1851.

THE Statement which the Commissioners for the Exhibition of 1851 have recently published, concerning their future policy in dealing with their Estate at Kensington Gore, is a reply to the memorial of the Metropolitan Gardens Association, a memorial in the same terms as that printed in NATURE of May 9 (p. 25). From the *Times* of July 9, it appears that various public bodies, Corporations, &c., who had memorialized the Commissioners, have been supplied with copies of this Statement. The result has been that further remonstrances have been addressed to the Commissioners. The Statement to which we refer is drawn up in ten paragraphs, the first of which quotes a sentence from the Commissioners' Charter of Incorporation, to the effect that they are to apply their resources "to increase the means of industrial education and extend the influence of science and art upon productive industry." By the side of this we may place a passage from the second Report of the Commissioners—the Report, in fact, which laid down in 1852 the broad lines upon which the Commissioners determined to act. The passage runs thus: "We are of opinion that if the surplus" (profits from the 1851 Exhibition) "were applied in furtherance of one large institution devoted to the purposes of instruction," &c., &c., "it would be productive of important results; whilst if subdivided amongst local institutions," &c., &c., "the effects produced would be comparatively insignificant."

The second paragraph of the Commissioners' Statement enumerates the number of museums and schools founded upon their estate, which form the "one large institution" originally contemplated. These, they state, prove "that their scheme has been in a great measure successful."

In the third paragraph the Commissioners argue in favour of now selling, leasing, or otherwise disposing of portions of their estate in order to do something more for promoting science and art than granting sites for public institutions. They then refer to the representations made to them, about 1878, by a deputation from certain large towns in England and Wales, with the object of obtaining funds which might be distributed as grants in aid to the formation of provincial Museums; and they explain why they rejected those representations at that time. The Commissioners' wisdom on that occasion has been justified by the number of important local municipal Museums of science and art which have been created by local effort, rates, and Government aid, as at Birmingham, Manchester, Nottingham, and elsewhere.

With respect to paragraph 5 of the Statement, which recognizes an expression of public antipathy "to the aggregation of public institutions in one locality" (South Kensington) of London, it may suffice to say here that the Commissioners did not feel the force of the arguments advanced against placing the Imperial Institute at South Kensington. But now, upon reconsideration, they admit the general justice of the representations from the country (eleven years ago) and from the metropolis (two years ago). They accordingly announce their intention "of disposing of portions of their estate for private building purposes" so as to raise "a considerable income" to be applied first to the reduction of the mortgage debt on their estate, and next to "the establishment of Scholarships" for science and art, and to the making of grants to "provincial local institutions."

This new departure was *in ovo* at least a year ago. Six months ago it was estimated that the portions of the "inner court" of the estate which the Commissioners were determined to sell "for private building purposes" would bring in an income of £10,000 a year. Recent circumstances have slightly modified the disposal of so large a portion of the "inner court" of their estate for private houses as was at first intended. There are difficulties in at once making a new public roadway from east to west across the northern gardens of the estate—it may be mentioned as a detail that this road is to be driven through the existing Science and India Museums—and housebuilders, not unreasonably, cannot come to terms with the Commissioners until these difficulties are got rid of. Instead, then, of aiming at £10,000 a year, the Commissioners contemplate getting an increase to their income of between £5000 and £6000 a year.

In thus diminishing their estimated new income by £4000 or £5000 a year, and so reducing it to £5000 or £6000 a year, we have it on good authority that the Commissioners do not intend to devote any of this money to the Imperial Institute. It is to be used, as shown in the Statement, (1) for the reduction of the mortgage debt, (2) for establishing Scholarships and Exhibitions, and (3) for making grants to "provincial local institutions." It is urged that no pressure in respect of clearing the mortgage debt on the estate exists. Last year it was £141,000. £5000 has just been paid off, so that it now amounts to some £136,000. In 1887, the announcement was made that in the three years from 1884 to 1887 the large sum of £40,000 had been paid off. The regular income of the Commissioners amounts to £12,000 from ground-rent and other sources, so that the repayment of the debt, under the mortgage upon the estate, is said to be in a healthy state, thanks to the shrewd economies and management of Sir Lyon Playfair. The founding of Scholarships and Exhibitions, as now proposed by the Commissioners, was certainly announced as one of the functions of the Imperial Institute. Accordingly the question has been asked, and not perhaps entirely without some sort of reason, why are the Commissioners to set about the same work as well, especially when in 1879 they decided against proceeding with a scheme of Scholarships which they had in contemplation at that time? An impression—as we now know, an erroneous one—is abroad that the revival of the Scholarship scheme and the sale of land for private houses are not due solely to an ingenuous wish on the part of the Commissioners to do the best for their public trust.

We are invited by those who disagree with the Commissioners to turn to the time when the Imperial Institute scheme was floated early in 1887, and when there was some discussion over the appropriation to the Institute of the land at South Kensington. Prof. Huxley warmly espoused the cause of an Imperial Institute, for reasons which he explained; but he regarded a congeries of Colonial and Indian commercial samples, reference libraries, conference and commercial intelligence rooms, deposited at South Kensington, as "fish out of water." Its proper habitat, according to the Professor, would be in the midst of men of business—in the City. To this a "Member of the Committee of Management of the Imperial Institute" responded by a letter in the *Times*, supporting the location of the Institute at Kensington, with arguments of economy, &c. He repeated, with a fervour which we are told might be ascribed to an original Commissioner for the Exhibition of 1851, and which should therefore have prevented the Commissioners from proposing to sell any part of their estate for building private houses, that the land at South Kensington had been "bought for the purpose of affording sites for public institutions by the far-seeing wisdom of the Prince Consort."

To elucidate the intentions of the Imperial Institute, Sir Frederick Abel gave a public address in the spring of 1887, in the course of which he said that "the organization of facilities, combined with material aid, to be provided to young artizans who shall afford some legitimate evidence of superior natural intelligence, and a striving after self-improvement, to enable them to abandon for a time the duty of bread-winning, and to work at one or other of the technical schools in London or the provincial centres, will be another object to which the resources of the Institute should be applied very beneficially." Not only was this to be in respect of "technical education," it was also to benefit "commercial education." Briefly put, one of the aspirations of the Imperial Institute was to establish Scholarships and Exhibitions for technical and commercial education. We can well understand the necessity at the time for publicly developing as fully as possible the intentions of the Institute. Half a million of money was openly quoted by its promoters as the amount necessary to the launching of the Institute. The recently published accounts show that the expectations of the promoters have not been completely realized, for not more than £300,000 has been collected for the Institute, and of that, some £140,000 has been set aside as an endowment fund to work and support the Institute. We may take it, then, that the Institute will start with an income of about £5000. Two years of "general administration," as it is termed, have cost £9134, of which £5236 went in salaries and wages. If these data of the expenditure, which has been incurred before the Institute is in working order, give any insight into what it will cost when at work, it is obvious that some portion of the Institute's proposed functions must be suspended.

But with this explanation of the situation, and notwithstanding the authoritative contradiction to the suggestion that the Commissioners are going to provide funds for the Imperial Institute, the Commissioners' opponents argue that, since many of the members of the Imperial Institute Committee are also Commissioners for the Exhibition of 1851, it is outside human nature to suppose that the ambitions of the one body exert no influence upon the actions of the other. And so, without actually putting money into the coffers of the Imperial Institute, the Commissioners may do as good, by undertaking the foundation of those Scholarships and Exhibitions which the Imperial Institute may not see its way to. It has been our wish, in thus frankly stating the objections and arguments which are raised to the Commissioners' proposals, to examine and discuss them in all fairness.

We may now at any rate dismiss the topics relating to the Imperial Institute, and offer a few remarks upon the Commissioners' proposals to establish Scholarships and make grants in aid of "provincial local institutions." The Commissioners are incorporated "to increase the means of industrial education, and extend the influence of science and art upon productive industry." One of their first steps, towards giving effect to the new proposals, must be to arrange for pulling down considerable portions of the buildings which house scientific and artistic collections. These operations will no doubt temporarily interfere with the study of those collections by the public from all parts of the country. This, however, is a minor point as compared with an apparent omission, on the part of the Commissioners, in framing their proposals, to take into account what the public have actually done towards establishing a system of science and art Scholarships, and towards securing grants in aid of provincial local institutions. A great organization, developed in the course of many years' experience, has arisen; it has, and must continue, to co-operate with local effort in extending the influence of science and art upon productive industry, so long as there is any local effort and any Parliament to appreciate that fact. This organization comes under the administration of the Vice-President of the Committee of Council on Education; its history and *modus operandi* are known to such Commissioners as Mr. Mundella, Sir Lyon Playfair, and Sir William Hart Dyke. The two former, it is almost needless to say, held the office of Vice-President before Sir William Hart Dyke, the present Vice-President. All these, however, have helped in continuing the policy of Mr. Lowe (now Lord Sherbrooke) and the late Mr. W. E. Forster—a policy, the central feature of which is to multiply the forms of Parliamentary aid to local bodies which take the initiative in themselves providing local means to extend the influence of science and art upon productive industry. Mr. Mundella, Sir Lyon Playfair, and Sir William Hart Dyke surely have brought their experiences before the Commissioners, in the discussions, upon the new proposals for Scholarships, and aid to provincial institutions. They must have told the Commissioners of the flourishing and growing co-operation between local effort and State aid; they must have explained the methods of its administration, and proved that experience and funds are necessary to pay for and organize an executive staff for the discharge of the same or similar functions towards science and art and local provincial institutions as are now discharged by Government. Roughly put, the Government aids to local effort are: (1) building grants for science and art schools; (2) grants towards the equipment of such schools; (3) grants towards the purchase of objects for local Museums; (4) grants towards founding local Scholarships and Exhibitions; (5) grants of national Scholarships and maintenance allowances whilst the holders of these Scholarships are undergoing instruction at one or other of the more prominent science and art institutions of the country; and (6) grants of Travelling Scholarships. The total cost of these varieties of grants, so far as Government is concerned, amounts, according to the Parliamentary Estimates, to not less than £20,000 a year. It is difficult to estimate how much local effort contributes, how much municipalities give out of local rates, how much private individuals give, &c. But putting aside great donations of tens, twenties, and thirties of thousands of pounds, towards building schools of science and art, technical schools, and provincial Museums, something like £40,000 a year are contributed by local effort, to meet which the yearly Government grant of probably £20,000 is made. It seems unlikely, but we shall gladly accept correction if we are wrong, that the Commissioners can allot more than £4000 a year for Scholarships and grants to provincial institutions. The beneficial and judicious administration of this £4000 would probably cost almost as much as if it were £20,000 a year. Have the Commissioners funds to pay for such administration? Apparently they have not. Will they therefore ask Government to administer their proposed grants? Government has certainly hitherto rather rebuffed advances of help made by the Commissioners, so that we confess to not at present perceiving how the Commissioners can successfully carry out proposals which seem to be beset with dilemmas.

On the other hand, if the Commissioners offer their aid to the country for its unconditional acceptance, it seems to us that they may be open to the charge of weakening local effort, and thus of decreasing the means of extending the influence of science and art upon productive industry. They realized, in 1852, that the subdivision of their means amongst local institutions would be productive of comparatively insignificant effects. A subdivision of smaller means, now that a new condition has arisen, does not under present circumstances appear to give better promise. The sacrifice of part of their estate, and the temporary disarrangement of a section of the national institutions upon it, are hardly warranted by what, at present, seems to be a scheme *in embryo*, the full development of which is not, in truth, forecast.

Without more precise information, therefore, we are rather driven to conclude that an effective and beneficial scheme of Scholarships and grants in aid of provincial institutions is beyond the reach of the Commissioners.

Under the presidency of the Prince Consort, the Commissioners took pains to collect a mass of information in regard to what had already "been done by the public in this country to promote the interests of science and the arts, and the diffusion of scientific principles amongst those engaged in their practical application." Thirty-six years ago they placed on record the evidence which led them to the opinion "that much zeal has been shown in this respect." If they would pause now, they might very well and usefully do again what they did thirty-six years ago—direct their inquiries particularly to the new developments and results of this zeal as demonstrated by its present co-operation with State aid. The result of such inquiries could but prove of high value to the Commissioners, and might, we venture to think, lead them to the conclusion that their present proposals are half a century too late, whilst the preservation of their estate, with its national institutions, including those already existing and those likely to exist, is really abreast of the serious wants of the time.

THE CYSTIDEA OF BOHEMIA.

Système Silurien du Centre de la Bohême. 1ère Partie, Recherches Paléontologiques. Continuation éditée par le Musée Bohême. Vol. VII. *Classe des Echinodermes. Ordre des Cystidées.* Ouvrage posthume de feu Joachim Barrande, publié par le Docteur W. Waagen. Pp. i.-xvii., 1-233; Plates I.-XXXIX. (Prague, 1887.)

To few is it given to accomplish the life-work that they have planned. Joachim Barrande, vast though his self-ordained task was, came nearer to his goal than do most men. Before the death of the venerable author in 1883, he had made some way with the last volume of the colossal "Système Silurien du Centre de la Bohême." The present work was destined to form the first section of Volume VII., "Echinodermes du Système Silurien." The plates were ready, the general portion of the work written and partly printed, and, on his death-bed, Barrande was still tracing out the descriptions of genera and species. The book has been completed by Dr. W. Waagen, who was appointed, in Barrande's will, editor of this volume. His admirable preface is rendered of practical value by the insertion of a complete list of Barrande's writings from 1846 to 1881.

The work itself is on the plan and in the style already familiar to us. It opens with an historical and critical account of the literature dealing with the Cystidea of the thirteen Silurian regions of the world. The term Silurian is, of course, used in the broadest possible sense. Even Sardinia, as one of these regions, has a section to itself, though the cystids of Sardinia have had less written about them than the snakes of Ireland. This retrospect brings us to 1883; the few observations published between that year and the end of 1887 do not affect the present work.

The second chapter is devoted to the morphology of the Cystidea, chiefly as exemplified in the Bohemian fossils. The arms especially are discussed at great length, and several tables show their presence or absence in the various species as yet known to science.

Then follow the detailed descriptions of the genera and species of Bohemian cystids. No classification is followed. On p. 49 a classification is indeed proposed, according to the number of major openings in the calyx. This arrangement, however, is impracticable, and apparently unnatural. Its chief merit is its simplicity; and yet, as the author naïvely complains, it is not so incomparably simple as the attempt of a certain English palæontologist to classify Silurian cephalopods according to their curvature. The order of description is therefore alphabetical, the only divisions being those of the three faunas. Such an arrangement, however, by no means does away with the necessity for an index, and the absence of that indispensable aid to the practical worker is the one great fault that we have to find with the work. At the present time some 240 species of Cystidea are known, and these belong to about 70 genera. The Bohemian species number 78, two varieties worthy of a name, and one or two indeterminable fragments. Of these species, 76 are here described for the first time, and the majority of them belong to new genera, of which 23 are here established. There are also represented the genera *Agele-*

crinus of Vanuxem, *Atelecystis* of Billings, *Echinosphaera* of Wahlenberg, *Lichenoides*, *Trochocystis*, and *Rhombifera* of Barrande, the latter formerly referred by him to the Pteropoda; and, lastly, the undefined *Cystidea*, which is reserved for the reception of eight or nine doubtful forms, some of which may, at a future date, form the types of yet more genera. It should also be noted that one species —*Echinosphaerites infaustus*, Barr.—has been taken by Prof. Neumayr as the type of his genus *Arachnocystis*. The same authority refers the somewhat doubtful *Rhombifera mira* to *Stephanocrinus*, and points out that *Staurosoma* is the same as *Tiaracrinus* of Schultze.

The genera of this group have been peculiarly unfortunate in the names attached to them. It is no longer necessary for palæontologists to cumber their generic names with the termination *ites*. This peculiar corruption of λίθος seems to set a stigma on fossils, as though they never had been living beings after all. The neontologist is ready enough to throw stones at the palæontologist; there is no need for the latter to supply him with ammunition. Prof. Lovén dropped this affix when editing the Cystidea in Angelin's "Iconographia Crinoideorum," and surely the names are long enough without it. Of far more importance is the correct use of the terminations *cystis*, *crinus*, *blastus*, and the like. We extend indulgence to certain old authors who gave such names as *Agelecrinus* and *Cryptocrinus* to cystids before the Cystidea were distinguished as a class; but when once the divisions were recognized, we must suppose that the eminent palæontologists who used these terminations attached to them some meaning. Even in 1843 we find Messrs. Austin suggesting that the names *Sycocrinites*, Austin, and *Echinocrinus*, Agassiz, "require amendment, as their terminations imply affinities which do not exist." *Apiocystis* means a pear-shaped *Cystid*, just as *Apiocrinus* means a pear-shaped *Crinoid*: the two terminations are *not* interchangeable. Posterity, for whom we labour, will lament that we had not the strength of mind to correct such names whenever we saw them to be misleading; but we ourselves should surely blame most severely those who still add to our perplexity. Why, for instance, should Prof. von Koenen give the names *Corylocrinus* and *Juglandocrinus* to two genera which he himself describes as Cystidea? In no other branch of science would such a use of language to conceal thought be tolerated. The present work we are glad to find free from such flagrant absurdities. The errors of nomenclature are slight: the name *Atelecystis*, Billings, the validity of which was upheld by Dr. H. Woodward, is, though not consistently, supplanted by its synonym *Anomalocystis*; there is also a want of consistency in writing *Pyrocystites pirum*. No attempt, however, has been made to revise the nomenclature of cystids foreign to Bohemia, in which direction much will some day have to be done.

Chapters iv. and v. are devoted to the geological and geographical distribution of Cystidea in general and of Bohemian cystids in particular. Chapter vi. describes the variations seen in the Bohemian species. The seventh and last chapter discusses the connection of these species with those of other countries. These questions are worked out, from a statistical if not from a philosophical point of view, in a large series of tables; a few graphic curve-diagrams would have been a more helpful guide through the wilderness of figures. The numbers of the species found in the various beds of Bohemia are:—

c.	*d1.*	*d2.*	*d3.*	*d4.*	*d5.*	*e1.*	*e2.*	*f1.*	*f2.*
7	12	12	4	46	2	2	3	0	2

This vertical distribution agrees in its main proportions with that observed in almost all other countries. The chief exceptions are the States of New York and Wisconsin, where a relatively large number of species are found in the Niagara limestone, and England, where seventeen species are recorded from Ordovician beds and nine from the Wenlock limestone: none of the Wenlock genera occur in the corresponding beds of Bohemia. The geographical diffusion of the Cystidea is very slight; the most widely distributed genera are *Agelecrinus*, *Atelecystis*, and *Echinosphaera*.

These elaborate comparisons and tabulations are, however, a little bit out of place in dealing with such a heterogeneous assemblage as the Cystidea. They are not a class, but a collection of puzzles to which we relegate all echinoderms that will go nowhere else. Barrande does indeed attempt a definition (pp. 23–24), but not one character mentioned is common to all Cystidea. What one really looks for in such a monograph as the present are new facts that may throw light either on the connection between individual genera and other classes of the Echinodermata, or on the origin and meaning of the various peculiar organs. Taking as guide the motto of Barrande, *C'est ce que j'ai vu*, we shall enter into no speculations, but shall mention such facts of morphological importance as appear to be new. The state of preservation of the Bohemian Cystidea is exceptionally bad; but it would be hard indeed if so rich an assemblage had not yielded to such an observer some interesting results.

Following the order adopted by Barrande in his second chapter, we begin with the stem. The stem of the Pelmatozoa typically consists of a single series of cylindrical joints with a central perforation. In the earlier crinoids the lumen is comparatively large; in most stalked cystids it is still larger. In *Atelecystis*, *Mitrocystis*, and *Trochocystis*, the proximal part of the stem consists of a double series of alternating plates which are thin and inclose a large hollow. In *Arachnocystis* the whole stem consists of four or five series of alternating plates. In *Dendrocystis* the plates forming the upper part of the stem can only be distinguished by their smaller size from those forming the calyx; below they merge into the normal series of single joints. *Cigara Dusli* is the fanciful name given to a stem entirely composed of small irregular plates, and probably belonging to *Lapillocystis fragilis*. These facts forcibly suggest that the Pelmatozoan stem originated as a mere evagination of the perisome. The curiously elongate *Pilocystis* (Pl. II. Fig. 26) may represent a still earlier stage in its evolution.

The test of Cystidea has usually been regarded as composed of one simple layer of plates. Eichwald, in *Lethæa Rossica*, mentioned an epidermis, but seems in many cases to mean by this nothing more than the outer surface of the plates. Lovén, in his monograph on *Pourtalesia*, seems to assume the existence of three elements or layers in the test. Barrande, however, has been the first to conclusively demonstrate that in a number of genera the main layer of the body-plates is closed, both inside and outside, by thin "*épidermes*," which appear to have been partially calcified. *Aristocystis* is the genus affording the most abundant material for the study of these coverings, but they have also been observed in *Arachnocystis*, *Craterina*, *Dendrocystis*, *Neocystis*, *Orocystis*, *Proteocystis*, and *Rhombifera* (*i.e. R. bohemica*): of *Deutocystis* and *Pirocystis*, the inner lining is the only part known. In *Mitrocystis* the great difference between the internal and external impressions (*vide* p. 65) *may* be due to the presence of an inner lining. The outer layer is continuous, and covers up all the pores of the body-plates; sometimes it is even thick enough to conceal their sculpture and the sutures. The inner lining appears to have passed up into the pore-canals, and to have been itself pierced at those points. There is, of course, no reason to suppose that this structure of the test was common to all the forms which we call Cystidea, but the observations of Barrande have undoubtedly opened a new field of investigation.

It has hitherto been usual to classify the Cystidea according to the disposition of their pores. Facts recorded in the present work are opposed to such an arrangement. In the simplest type, canals run right through the inner lining and the principal layer of the test, usually in a curved course: we may call these "haplopores"; they are best seen in *Aristocystis bohemica*. In other species of *Aristocystis*, *e.g. A. subcylindrica* and *A. grandiscutum*, the distal ends of two adjacent haplopores are often connected by a horseshoe-shaped groove on the surface of the middle layer. In the allied *Craterina* this groove appears to have expanded into an oval depression into which open the two canals. This, the familiar diplopore, is also seen in *Proteocystis*. In all these forms the pores do not open to the exterior, but are closed by the outer layer: the horseshoe groove and the oval depression are therefore nothing more than closed horizontal canals connecting the vertical canals; in these genera, at all events, the canals can have had nothing to do with tube feet. The structure of the hydrospire elements in such forms as *Echinosphaera*, *Arachnocystis*, *Caryocystis*, is essentially the same; that is to say, two vertical canals connected by a closed horizontal canal: the only difference is that the two vertical canals are separated by a suture line instead of being on the same plate. From a position originally just beneath the outer layer these horizontal canals seem to have sunk into the main layer of the test, and in *Caryocrinus* they are actually internal. *Rhombifera* (*sc. bohemica*) and *Homocystis* show the gradual specialization of certain portions of the test as canal-bearers: here it seems that the horizontal canals become more developed in proportion; in fact, they appear eventually to assume the whole function, whatever it may be. In such forms as *Lepadocrinus* they alone remain, and here they no longer connect the adjacent plates, but are transformed into two separate sets of folds. As to the function of these organs, Barrande regards it as respiratory, but drops the term *hydrospire*, for the quaint reason that they show no *spiral* structure. Instead, he calls them *hydrophores*. But he also applies this term to certain organs which can hardly be homologous with pore-rhombs. Around an opening, the interior of the calyx appears divided into five compartments; from the opening there passes into each compartment a branch, which subdivides into five or six smaller branches, and each of these ends in a double tubercle. It is impossible to see whether these branches were hollow tubes or no; they have no connection with the exterior, except at the central opening. These *hydrophores palmées* occur in *Aristocystis*, *Pirocystis*, and *Craterina*, forms already abundantly provided with canals: though simulating the hydrospires of Blastoidea as seen in section, they have an exactly contrary position. Neumayr thinks that the opening which they surround is the mouth, and that they are subtegminal ambulacral grooves. How this can be, when their distal ends are unconnected with the exterior, is not easy to understand. Barrande, moreover, cannot say whether they are at the oral or aboral pole. A comparison of Figs. 28 and 32 on Pl. XXIX. suggests that they are at the aboral end, and that the large opening represents the axial canal of the stem. May they not be connected with nerve-cords passing from a chambered organ?

As regards the major openings of the Cystidean calyx, the accepted views are confirmed by Barrande. Somewhat unaccountably, however, he speaks of the anus of *Agelecrinus* as the mouth (p. 84); perhaps he intended to quote Vanuxem, in which case the oversight is the editor's. In addition to the mouth, anus, and genital pore, Barrande describes for *Aristocystis* a slit-like aperture close to the mouth. This he regards as an organ hitherto unknown. At the same time he points out that its position is similar to that occupied by the peculiar folded structure described by Volborth in *Sphaeronis Leuchtenbergi*. More closely still does it resemble the "reniform groove," or "semilunar pore," figured by Forbes in the fossils which he called *Apiocystis* and *Echinoëncrinus*. We notice that *Atelecystis* is still quoted as having anal and genital openings, although neither in this genus nor in its near relation *Mitrocystis* do the Bohemian species show them. The fact is that even in *A. forbesianus* they have never really been found; the appearances described are only accidental. The true openings in all the Anomalocystidae must be looked for in the neighbourhood of the arms.

Although Barrande enters very largely into the question of the arms, he has brought out no results of importance. The arms of *Arachnocystis infausta* are perhaps more developed than those of any other cystid: it is curious how closely they resemble the stem in structure; one would almost imagine that they had originated in the same manner. A similar structure is observable in the process of *Dendrocystis* which Barrande regards as a ventral tube: there is, however, no reason to call it anything but an arm; and at the same time we may remember that the ventral tube of *Poteriocrinus*, to which Barrande and Trautschold have compared it, is not improbably itself derived from an arm.

Such are the points of greatest morphological interest in this fascinating work. Many peculiar and wonderful forms, such as *Acanthocystis*, *Trochocystis*, *Neocystis*, *Mespilocystis*, *Ascocystis*, and *Cystidea nugatula*, must be passed by with mere mention. The question of classification we have left where Barrande preferred to place it—on the shelf. Systematists may even wish that many a one of these new forms had been left in the earth—*irrepertum et sic melius situm*—and not dug up to disturb existing arrangements. We would not, however, seem ungrateful; rather let us hope that the future parts of this volume, though deprived of the care of the great palæontologist, may be equally fruitful of new and interesting facts, and that, in the hands of Dr. Waagen, they may, no less than this one, add still fresh lustre to the name of Barrande.

TEXT-BOOK OF PATHOLOGY.

Text-book of Pathology. By Prof. D. J. Hamilton. Pp. 719. (London: Macmillan and Co., 1889.)

ABROAD, it is usual for a pathologist to devote his whole life and energy to one subject, and to pay little or no attention to the clinical side of disease, concentrating all his attention on the anatomical and histological aspect. This system has both its advantages and its defects. As his future success in life depends solely upon his reputation as a pathologist, he is stimulated to write frequently and much; and one practical outcome is a large number of books, in both German and French, on pathology. These are of very varying excellence, some being mere compilations of the current standard works, while a few represent the results of a mature experience. For naked-eye pathology, English students have an unequalled work in Wilks and Moxon's "Pathology," of which a third edition has recently appeared. Morbid histology is a science of comparatively recent date, and English authors have hitherto confined themselves to writing short manuals for students, which have been supplemented by translations of the more elaborate foreign works.

This "Pathology" is the first English book which has attempted, in its completeness, to compete with the larger Continental works, and as it is the outcome of several years' experience, of one who is already well known for the original work he has published on many of the questions, it will meet with a hearty welcome. The author takes a very wide view of pathology, and includes under this term morbid anatomy, pathological histology, physics, chemistry, and comparative pathology. Theoretically, this is undoubtedly right; but it is extremely inconvenient, when a book is overweighted by collateral subjects; and we think the author would be well advised in a future edition, to omit the chapters on bacteriology and on the experiments which he conducted to illustrate the circulation of the blood. The greater portion of the information on bacteriology is of necessity a repetition of what is given in any text-book on the subject, and is therefore superfluous, except for the purpose of making the book theoretically complete. The experiments on the circulation should be relegated to a book on physiology.

The book commences with a very full account of the method of making a *sectio cadaveri*, with which we would in the main agree. Our experience, however, is entirely opposed to the separation of the heart from the lungs in the body, as he directs. We believe much more may, in a difficult case, be made out if the lungs and heart be removed, and examined together, the amount of blood in the various cavities of the heart having been previously noted.

One of the most valuable portions of the book is that which deals with the preparation of specimens for the museum and for microscopical examination. For the preservation of intestines and other delicate tissues as jar-specimens in a museum, the author recommends a saturated solution of boracic acid; and for eyes, brain, &c., glycerine jelly. Full details are given for the preparation of large sections of the brain by the gelatine-potash method devised by the author, by which he has been able to uniformly expand the sections, so as to more readily show the course of the various bundles of fibres.

The middle third of the book is occupied by a discussion of general pathological processes. The phenomena of inflammation are very fully discussed, and the author gives a good *résumé* of the views now held on the subject, and also of his own conclusions. He considers the blood-pressure to be the cause of the extrusion of the corpuscles which occurs in inflammation. In discussing the phenomena of inflammation of the cornea, he concludes that at first there is an influx into the cornea, which distends the canals and breaks up the endothelial plates; as a consequence, the so-called branching cells of the cornea, which were really the liquid in the plasma spaces, disappear; at the same time the nuclei of the endothelial plates proliferate. The fusiform nuclei which used to be looked upon as the nuclei of the branching cells, he considers to be the nuclei of the fibrous bundles, and as these run in laminæ of parallel bundles, which lie at right angles to those of the adjacent laminæ, the so-called spear-head bodies are formed by their proliferation. The pus comes both from the connective tissue corpuscles and from leucocytes. In granulation tissue, the author holds that the capillary vessels are mainly old capillary loops from the subjacent tissue, which have been pushed up by the pressure of the blood inside them, when the tense surface of epithelium has been destroyed; and he draws attention to the absence of granulations in a wound on the pleura or peritoneum where the surface pressure is still kept up, and considers that the vessels found, when the pores of a piece of sponge applied to a wound become vascularized, are at first not new vessels, but those of the tissue which have pushed up into the pores.

The third part deals with the diseases of the various organs and tissues. Some interesting facts are given as to the means by which tubercle may be spread:—

(*a*) By inoculation. When the poison is introduced subcutaneously, the disease is reproduced with great certainty. It is remarkable, however, how rarely the disease is contracted through superficial scratches by pathologists; for, although tubercle bacilli have been found in *post-mortem* sores, the author thinks no one has become tubercular in consequence; but this is too sweeping a statement.

(*b*) Through ingesta. Rabbits and guinea-pigs readily become tubercular when fed upon tubercular tissues or sputum, while dogs are less readily infected. Herterich has recorded the case of a healthy widow with two children, who married a second husband who had phthisis, by whom she had three children. She herself became phthisical, and her two youngest children developed deep yellow-coloured ulcers on the mouth and fauces, and ultimately general tuberculosis. The children had been fed on food which the mother had previously chewed. Reich records ten cases of tubercular meningitis in a country village, occurring within fifteen months in the practice of a phthisical midwife, who was in the habit of sucking the mucous from the mouths of the new-born infants, and of blowing air into their lungs. Pigs fed upon the milk of tuberculous cows became tubercular in five weeks.

(*c*) By inhalation. Animals after a few inhalations of tubercular sputum, disseminated in a spray, readily became infected. Koch holds that no other substances than tubercular products when introduced into an animal will produce tuberculosis.

The *résumé* of the changes which take place in the blood in various diseases is most complete and up to date. The latter part of the book deals with the diseases of the circulatory organs.

Among alterations which are desirable in a new edition we would suggest that the forms for the *post-mortem* reports which occupy four pages should be omitted; or, if not, they should be made much more complete. Many important headings, such as lymphatic glands, joints, prostate, &c., are wanting. Fig. 25 is an unfortunate illustration of lardaceous disease of the liver in which the liver cells are affected, and should be replaced by a more typical case with healthy cells. We would demur to the statements that lymphadenoma produces great anæmia and infiltrates tissues—that is, in the sense in which sarcoma is said to infiltrate. The growths extend only along lymph-channels, and do not infiltrate outside these. On p. 82, sulphide of potassium should be sulphite.

We congratulate the author on the general excellence and practical nature of his book, and shall await with interest the second volume. The arrangement of the type, the paper, and the illustrations are unexceptionable, and reflect the greatest credit upon all concerned.

OUR BOOK SHELF.

A Graduated Course of Natural Science. Part I. By Benjamin Loewy, F.R.A.S. (London: Macmillan and Co., 1889.)

THIS is an admirable little book which has been prepared for the use of teachers and students in schools where elementary ideas of physics and chemistry form part of the course of training. It is intended for elementary students only, and it is not too much to say that the various experiments and inferences are well within the scope of every boy and girl of ordinary ability. It is but to be expected that during his twenty years' experience the author has become thoroughly acquainted with the difficulties met with by young students, and with the best methods of overcoming them.

An experiment is first described, and the inferences to be drawn are then discussed, the simple conversational style being especially suitable for young pupils. The subjects are arranged in a very natural order, and it would be difficult to suggest improvements. Very practical suggestions are made as to the best way of arranging for each student to perform the experiments. A simple board, about 3 feet long by 18 inches wide, temporarily screwed to the top of the desk, has been found sufficient to accommodate two or three pupils, so that it is an easy matter to have thirty or forty working at the same time. To make the book more useful to teachers, a series of questions has been put at the end of each chapter.

We strongly recommend the book to the notice of teachers likely to be interested in the subjects of which it treats.

Flora of Switzerland for the use of Tourists and Field-Botanists. By A. Gremli. Translated from the Fifth Edition, by Leonard W. Paitson. (London: David Nutt, 1889.)

ENGLISH visitors to Switzerland who happen to be interested in botany must often have regretted that they did not possess a really good hand-book of the Swiss flora. The translator of Herr Gremli's well-known work has provided a volume which will exactly meet their wishes. The original book has been widely circulated in Germany, and its materials are so ample, and so carefully and intelligently arranged, that it well deserves its popularity. In the fifth edition many improvements were made, and these are, of course, embodied in the present rendering. Mr. Paitson has also been able to include the new matter presented in the French translation by M. J. J. Vetter (1885), and corrections and additions published (1887) in the latest—the fourth—of Herr Gremli's supplements. Although the work is intended in the first place for persons beginning the study of botany, it contains much information with regard to new species that will be of service to more advanced botanists. We may note that the English volume is clearly printed, and that it is of a size convenient for the use of tourists.

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.*]

Coral Reefs.

I AM obliged to Mr. Murray and Dr. Guppy for their courteous replies to my questions. Mr. Murray knows how pleasant a duty it is on the part of Admiralty surveyors to collect materials for the investigation of men of science like himself. Perhaps he will allow me to say that the theory of wave action spreading out the loose materials of a volcanic island is difficult to understand in view of the fact that islands in the same locality, such for instance as Mokongai and Wakaya in the Fiji Group, have their barriers far away from the land on exactly opposite sides. If he will excuse repetition, I desire again to point to the Exploring Isles, and to the great distance between the barrier and the island of Vanua Mbalavu; also to the fact that the waves, for all but a few days in the year, attack the island from a direction varying between south-south-east and east-north-east, principally east-south-east. Although there is much upraised coral at the north end of Vanua Mbalavu, the formation is chiefly volcanic.

The shallow nature of the Na Solo lagoon is, I presume, due to the detritus from the now sunken island, and the fragments from the reef washed over by the heavy seas at high tide. The bank west of Ono, in the Kandavu Group, is terminated by a sunken barrier, similar to that south of Viwa and north-west of Mbengha; and is not a continuous reef awash, because of the muddy streams from Ono sweeping to leeward, and also for the reason, admitted on all sides, that coral does not grow with so much vigour where there is no surf.

Dr. Guppy's simile, of an engineer having constructed and afterwards repaired a bridge, is not, in my opinion, a good one. A bridge is a structure accomplished on mathematical principles, good or bad. If good, it will stand; if bad, it will sooner or later fall. Mr. Darwin's theory, like other theories, is not capable of mathematical proof; and it is deduced from personal observation only in a very limited degree. The second edition of his work indicates, that after thirty-two years' further experience in weighing, deducing, and generalizing of a similar character in other branches of natural history, and receiving the views of those opposed to his theory on this special subject, he still adheres to his original opinion. The principle of his work was, in all cases, very much the same; and, considering the labour which he devoted to the first study of the question several years after he returned from his voyage, it is hardly conceivable that the origin and formation of coral reefs did not occupy a considerable share of his attention in the long interval between the publication of the first and second editions of his book. As to acquaintance with the objects of his writings, he had none, I presume, with that horrid creature with the swim-bladder from which he believed we are all descended; nor with most of the animals which have formed the connecting links between that distinguished progenitor and man; but, nevertheless, his great collection of facts and evidences have been of sufficient weight to revolutionize the history of creation, and to pervert hundreds of thousands from their faith in the poetical narrative of Moses.

However, Dr. Guppy is correct in saying that there are certain upraised ancient reefs in the Lau group of Fiji. Lieut. Malan was no doubt alluding to the islands of Tavuthá, Naiau, and Kambara, which have every appearance of atolls lifted out of the sea, for they are coral islands of considerable height, with an exterior rim and depression in the centre, between 150 and 200 feet deep. It does not follow that they may not form *now* part of a descending area; nor that the Bukatatanoa and Reid Reefs may not be participating in the movement. It is remarkable that only one reef has yet been discovered which connects the atoll awash with the island many hundreds of feet high which has been, to all appearance, an atoll in past ages. As far as I am aware, there is no island known, except Aldabra (which has a lagoon dry at low water, and is, therefore, an abnormal instance), of coral formation, with a lake in the centre and openings on the lee side; in such a stage as an atoll would be if it was elevated, say, 20 or 30 feet; nor do I believe that anyone has yet seen an upraised island *barrier* reef. The sight would be so phenomenal, that the news of its existence would speedily become public property. It must be remembered that, while proofs of upheaval are easily detected, direct *evidence* even, of subsidence, is most difficult to obtain. All searching under water is groping in the dark.

I may here remark, as it is our common object to arrive at the truth, and surveyors are not special pleaders, that there is an error in Mr. Dana's examples of subsidence (p. 310, "Coral Reefs," Darwin, third edition). Nanuku Islets are cays on a spur from a barrier reef, and Bacon Islets are formed of coral. It is unfortunate that these should have been inadvertently taken as types so late as 1885, three years after the charts were published, though it is easy to understand how Mr. Dana was mistaken in his first book when he had to rely simply on the excellent sketch made by the officers of Wilkes's expedition, to which he was attached; but these mistakes do not necessarily invalidate the conclusions of the experienced naturalist, who, had he thought of it, could have selected other and better examples from the same group.

It would be premature to discuss the cases of the Tizard and Macclesfield banks before Dr. Bassett-Smith records the results of his examination of the specimens collected, in pursuance of Captain Wharton's directions, chiefly by himself and Lieut. Parry, of the *Rambler*; but this much may be said—the existence of a submarine cliff is established in the former, and the sectional slopes have a great resemblance to those of mountains. The condition of the Itu Aba and its surrounding reef appears to favour Mr. Murray's views; but the general state of the reef does not, as far as I can see, disprove the theory of subsidence. The one Macclesfield bank section is not at all like that of a sinking mountain; and the condition of the coral on the top might indicate either a downward or upward movement, or neither. If we find, as in both these cases, a mixture of dead and live coral on the rim of an atoll, the inference seems more in favour of subsidence than elevation. It implies that a sudden descent to a depth beyond that in which the less hardy individuals of the species can flourish, has killed the growing insect; and that a new effort is being made to regain the surface. Specimens of reef-building corals were brought up from depths below even 30 fathoms; but, as far as the imperfect appliances which we have at present could help us, there was no evidence that *masses* of coral were at all common below 13 fathoms. The condition of the slopes could be safely compared to the banks of a river stream with the blades of grass growing thinner and thinner as the distance from the water was increased (Darwin, p. 111).

In the case of the Bukatatanoa, and other large reefs of a similar character, my difficulty with respect to Mr. Murray's theory is this: if corals commenced to grow on sediment which had lodged on a submarine inequality, why should nearly all parts have kept pace so evenly in their growth? The highest portion of the bank on which the Bukatatanoa Reef—according to the theory of Mr. Murray—rests, would surely not be around the sides, but somewhere in the centre. There would be a summit of some kind, to which the sediment would be first attracted. Is it not most improbable that first the pelagic organisms which are dead, and then the coral polyps which are alive, should maintain an even contour around three sides of a bank and many miles away from the highest part of it, and arrive at the surface of the ocean much about the same time? If it is said, How do you know it arrived at the surface at the same time? I point to the connected form of the barrier. According to Mr. Murray, had it not done so, it would have formed innumerable rings instead of being connected, without a break, for so many miles.

Reid Reef, to the north of Bukatatanoa, is a still more remarkable instance. Here, there is a feature, which Mr. Murray mentions, quite apparent, viz. the paucity of coral heads in a lagoon where the barrier is uninterrupted; but the difficulties which I have ventured to place before him are greater than ever: (1) Why should wave-action distribute a bank on the weather as well as the lee side of the land? (2) Why should the insect reach the surface simultaneously on all sides, as shown by the continuous reef and the uniformity of its breadth? To the best of my recollection, the islets within this barrier are of volcanic origin, but the point is not material.

With reference to Mr. Murray's explanation of the deficiency of reef under Mbuke Levu (Mount Washington), may I point out that it is of great assistance in showing why, when discussing subsidence, it is not necessary to hesitate for examples at those islands which have a barrier on one side and a fringe on the other. On a cliffy, steep side, the sinking fringe would, of course, remain very close to the new coast-line, and, if it assumed the barrier form at all, would rapidly become filled with pieces from the land.

The fragmentary character of the Great Barrier Reef of Australia does not seem to have excited the attention it deserves in this controversy. I believe that there are innumerable passages through it, and that, instead of being termed a "barrier," it might better be described as a collection of large patches.

W. USBORNE MOORE.

8 Western Parade, Southsea, July 9.

The Hailstorm in Liverpool.

Sunday, June 2.—A very sultry afternoon, with heavy thunder-clouds in the south-west and west, and continual rumblings from the same direction, the storm evidently passing over the Dingle and Toxteth Park. Soon after 3.30 p.m. lightning became visible and the storm broke.

At first a few large drops of rain fell, making patches of $1\frac{1}{2}$ to 2 inches in diameter on the cement. In a minute or two, large lumps of ice came slowly down, rebounding to an astonishing height. As the stones became more numerous they decreased considerably in size and fell with greater force. This lasted for ten or twelve minutes. The rain had nearly ceased during the height of the storm, but began again towards the end for a short time. I immediately collected some stones off the grass, and placed them in a dish on some blotting-paper.

They were evidently of two classes; the one having clear ice kernels, the other white misty ice. If the stone was large the kernel was surrounded with another coating of the opposite kind of ice, a dark line intervening between the two, and here and there I noticed a third or fourth layer.

Many in themselves spherical had a pear-shaped appendage, which, however, soon melted away. One or two (Fig. 4) had the second layer thinner than the others, making a hollow between the centre and exterior layer, both above and below.

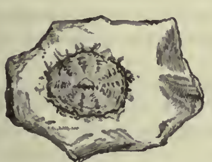
I found one of a most curious construction (Fig. 3). The stone was all composed of white ice except at one end. The white ice seemed to terminate like the petals of a flower, closing in round a centre of clear ice. This construction was entirely formed below the surface, the stone being otherwise smooth. I could not take accurate measurements owing to the absence of a correct scale, but approximately the stones I drew measured as follows:—

	Breadth.		Width.		Thickness.
(1)	$\frac{12}{16}''$	...	$1''$	...	$\frac{8}{16}''$
(2)	spherical, about		$\frac{10}{16}''$	...	
(3)	$\frac{15}{16}''$	...	$1\frac{3}{16}''$	...	$\frac{14}{16}''$
(4)	$\frac{14}{16}''$	...	$1\frac{4}{16}''$	...	
(5)	$\frac{14}{16}''$	...	$1\frac{5}{16}''$	...	$\frac{10}{16}''$

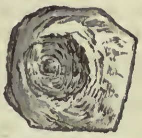
The stones had all a metallic taste and also a flavour of ozone.

I have examined some of the stones under the microscope. All have an air-bubble at the centre, and I thought in some I could distinguish a speck of sand or grit as well. The kernel appears to have infinitesimal cracks in the ice, going round the central bubbles in circles. Sometimes these are not spread out all round, but run up to the centre in spokes, widening out as they reach the edge. The dark line between the coatings appears to be composed of small pear-shaped air-bubbles lying with

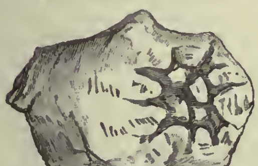
1.



2.



3.



4.

5.

their narrow end towards the centre, and here and there in the ring are specks of grit or dust.

In the pear-shaped prominences the minute ice cracks appear to be formed in waving lines.

In some (Fig. 4), the air-bubbles are formed near the surface round the second or third layer, and are much larger; in others (Fig. 5), they appear in the kernel instead of the spoke-like formation of cracks.

C. D. HOLT.

Sefton Park, Liverpool.

Use or Abuse of Empirical Formulæ, and of Differentiation, by Chemists.

PROF. THORPE'S review of the work of Mendeleeff suggests to me a question I have several times previously thought of putting, viz. whether chemists are not permitting themselves to be run away with by a smattering of quasi-mathematics and an over-pressing of empirical formulæ. I do not make the accusation; I merely put the question as one suggested by an incomplete and superficial perusal of one or two recent memoirs.

To make my meaning clear, I will state a few facts, and if they are unnecessarily obvious I shall be glad to find them so.

Take percentage composition (p), and specific gravity (s); s is a function of p, and the question is, whether it is a continuous or a discontinuous function. To obtain an answer to this question, the best determinations of s should be plotted on a large scale in terms of p, with the probable limits of inaccuracy laid down, and then the curve should be examined to see whether it possesses, at the points of definite constitution, any kind of discontinuity, whether of slope or curvature. The answer may come out, either that such discontinuity certainly exists, or that it possibly exists, or that, if it exists at all, it must be below a certain specifiable order of magnitude. One of these is the definite kind of statement that can be made, and nothing else.

In order to assist the eye in forming a judgment, some form of mechanical integrator or differentiator might legitimately be run over the curve, provided due care were taken to avoid the creeping in of errors; but I doubt whether anything could be certainly detected in the derived curves that ought not to be visible in the original curve itself.

The process adopted by chemists seems a less satisfactory plan. I speak under correction. They assume some elementary form of empirical expression for the function, say a quadratic expression with three arbitrary coefficients, and they determine these coefficients to suit three points on the curve, first for one portion and then for another, taking these portions in the stages between one definite constitution and another; they thus obtain a set of quadratic expressions for s in terms of p, each with a more or less different set of coefficients: in other words, they find bits of parabolæ which more or less fit successive portions of the actual curve. They then differentiate each of these, and plot $\frac{ds}{dp}$, and they appear to be struck with the fact that, for each portion, these plottings come out precisely rectilinear; while with the observation that discontinuities exist between successive portions they seem quite pleased.

They sometimes go on to plot $\frac{d^2s}{dp^2}$, and to deduce fresh support for their facts by means of it.[1]

Now, were it not that eminent persons appear to lend their names to this kind of process, one would be inclined to stigmatize this performance as juggling with experimental results in order to extract from them, under the garb of chemistry, some very rudimentary and commonplace mathematical truths.

I would not be understood as casting any doubt on the *results* which may, by ingenious and clear-sighted persons, have been arrived at, even by so questionable a process: I would not be so understood, partly because those results lie out of my province, partly because the hypothesis of definite constitution for solutions or for alloys seems a very probable one, partly because I have myself plotted the s p curve for dilute ethyl alcohol, and clearly perceive the varieties of slope and curvature detected by Mendeleeff, though the changes are scarcely so sharp and definite at definite points as one might wish them to be in order to support the *a priori* improbable hypothesis of actual discontinuity. But what I want to assert, perhaps unnecessarily, is, that no juggling with feeble empirical expressions, and no appeal to the mysteries of elementary mathematics, can legitimately make experimental results any more really discontinuous then they themselves are able to declare themselves to be when properly plotted.

Liverpool, June 29. OLIVER J. LODGE.

[1] Although Prof. Thorpe's review *suggested* the writing of this letter there is nothing contained in that review which prompts these remarks. Prof. Thorpe does not appear to have fallen into the errors which, in the writings of some chemists, I fancy I detect.

CHEMICAL AFFINITY.

IN the older days, chemists were willing to think that, when they had said of a chemical occurrence, "It is a manifestation of the affinities of the reacting bodies," they had given a fair explanation of the occurrence. Nowadays, we rather avoid the term affinity. The modern chemist is not comforted by the word as his fathers were. Phrases, he knows, have a way of decoying a man to destruction. But, although he does not use the word affinity so much, the chemist is more eager than ever to understand the modes of action of affinity.

Since the latter part of the last century, the prevalent views regarding affinity have fluctuated between the doctrines of Bergmann and Berthollet. Bergmann taught that the causes of chemical action and gravitative attraction are identical; this cause being manifested, in one case, in an attraction between minute particles, and, in the other case, between comparatively large masses, of bodies. Further, he said that the result of chemical attraction between different kinds of particles is a change of composition wholly in the direction of the stronger attraction. Hence, according to Bergmann, substances may be arranged in the order of their affinities towards some standard substance. If A, B, and C are each capable of reacting chemically with D, and if the affinities of the three substances are in the order A, B, C, this means that addition of A to the compound BD, or to the compound CD, will cause the production of the new compound AD, and the liberation of B, or C.

Berthollet, like Bergmann, regarded chemical affinity as an attraction between minute particles; but he asserted that affinity is conditioned by the physical properties of the attracting bodies, and also, and very specially, by the relative masses of these bodies. A relatively small attraction may overcome a greater, if the mass of one of the attracting bodies is largely increased relatively to that of the other. Berthollet's view is expressed by himself in the words, "Toute substance qui tend à entrer en combinaison, agit en raison de son affinité et de sa quantité."

These two conceptions still divide the allegiance of chemists. Berthelot's *law of maximum work* is the modern form of the Bergmannic doctrine. Guldberg and Waage's *law of mass-action* puts Berthollet's statement into exact form, and includes in its expression the conception of equivalency—a conception which has been developed since the days of Berthollet.

A great deal of work on chemical affinity has been carried on within the last few years. Ostwald has recently published a memoir of first-class importance. The present seems a good opportunity for endeavouring to give a sketch of the position of the subject.

The enunciation of Guldberg and Waage's law of mass-action, and of the *principle of the coexistence of reactions*, marks the beginning of the distinctly modern era of the study of affinity. The law of mass-action, first clearly put forth by the Norwegian naturalists in 1867, states that *chemical action is proportional to the product of the active masses of the substances which take part in the reaction.* The *active mass* of any member of a chemical system is defined to be the mass of that substance, stated in chemical equivalents, in unit volume of the system. Thus, if in a solution of hydrochloric acid, sulphuric acid, and caustic soda, the substances are present in the ratio

$$2HCl : H_2SO_4 : 2NaOH,$$

the active masses of the three substances are 1, 1, and 1 respectively, H_2SO_4 being taken as one equivalent of sulphuric acid. The investigations of Guldberg and Waage, and others, more especially of Ostwald, have shown that, if more than one member of a system is undergoing chemical change, each change proceeds as if it were independent of the other, and each substance obeys the law of mass-action. This statement is called by Ostwald the principle of the co-existence of reactions.

But the amount of chemical change which occurs when substances react is conditioned not only by the active masses of the substances, but also by their chemical nature, their states of aggregation, the temperature, and other variables. In their first memoir, Guldberg and Waage grouped these variables together under the name *coefficient of affinity*.

Let two substances, P and Q, react in solution to produce P′ and Q′, and let P′ and Q′ by their reaction re-form P and Q; let the active masses of P and Q be represented by p and q, and the active masses of P′ and Q′ by p' and q'; further, let the coefficient of affinity for the reaction between P and Q be represented by k, and the coefficient of affinity for the reaction between P′ and Q′ by k'; then the amount of decomposition of P and Q which occurs will be proportional to the product kpq; and the amount of decomposition of P′ and Q′ will be proportional to the product $k'p'q'$. When the equation $kpq = k'p'q'$ is fulfilled, the system will be in equilibrium.

The ratio k'/k is found by throwing the equation into the form—

$$(P - x)(Q - x) = k'/k\,(P' + x)(Q' + x);$$

where P, Q, P′, and Q′ represent the masses, stated in equivalents, of the four bodies initially present, and x represents the number of equivalents of P and Q which disappear, and also the number of equivalents of P′ and Q′ which are formed, when equilibrium results. Experimental measurements of P, Q, P′, and Q′, and x are required; from these the ratio k'/k is calculated, and, from this, values are found for x for different initial values of P, Q, P′, and Q′.

In their earlier treatment of the equation of equilibrium, given above, Guldberg and Waage spoke of the force which brings about the formation of P′ and Q′ being held in equilibrium by the force which brings about the re-formation of P and Q. The word *force* was used with a somewhat vague meaning, and certainly not with the meaning given to it in dynamics. Following the example of van 't Hoff, in their later memoirs the Norwegian naturalists regard chemical equilibrium as resulting when the velocity of the direct change—*i.e.* in the above case the change of P and Q to P′ and Q′—became equal to the velocity of the reverse change, *i.e.* in the above case the change of P′ and Q′ to P and Q. The equation of equilibrium arrived at by applying this conception is identical with that already given. By *velocity of the change* is to be understood the ratio of material chemically changed to time used in the change. Ostwald's analysis of the criterion of equilibrium, viz. that the velocities of the direct and reverse changes are equal when equilibrium results, is somewhat as follows. Let two bodies, A and B, be changed to A′ and B′; let the active masses of the four bodies, stated in equivalents, be p, q, p', q'; let x be the number of equivalents of A and B changed to A′ and B′, and the number of equivalents of A′ and B′ changed to A and B, at any moment; and let ξ be the value attained by x when equilibrium results; then

velocity of direct change $= (p - x)(q - x)c$; and velocity of reverse change $= (p' - x)(q' - x)c'$; and the velocity of the total change $= (p - x)(q - x)c - (p' + x)(q' + x)c'$.

Then $x = \xi$, and the velocity of the total change $= 0$, *i.e.* equilibrium results, when

$$(p - \xi)(q - \xi)c = (p' + \xi)(q' + \xi)c'.$$

This is the same equation as that given by Guldberg and Waage. But in this equation c/c' represents the ratio of the velocity-coefficients of the two parts of the change, whereas the ratio k/k' was called the ratio of the affinity-coefficients.

The simplest case in which to apply the above form of the equation of equilibrium is when A and B are caused to react in equivalent quantities without addition of A′ or B′; in this case $p = q = 1$, and $p' = q' = 0$, and the equation has the form

$$(1 - \xi)^2 c = \xi^2 c';$$

hence

$$\frac{c}{c'} = \left(\frac{\xi}{1 - \xi}\right)^2.$$

By determining ξ, *i.e.* the number of equivalents of A and B changed, and $1 - \xi$, *i.e.* the number of equivalents of A and B remaining unchanged, when equilibrium results, the ratio of the velocity-coefficients is found. This equation has been applied to varied classes of changes. Thomsen's measurements, by thermal methods, of the distribution of a base between two acids when one of the acids interacts with the salt of the base with the other acid, confirm the equation. Ostwald's measurements, by volumetric methods, of the same reaction which Thomsen examined by thermal methods, also confirm the equation. And the equation is confirmed by the determinations, made by Berthelot and P. de Saint Gilles by chemical methods, of the quantity of ethereal salt formed when an acetic acid reacts with an alcohol. The accuracy of the equation has also been confirmed by applying it to physically heterogeneous systems consisting of solids and liquids or gases; Ostwald (in his "Lehrbuch der Allgemeinen Chemie") gives the necessary forms of the equation for different cases.

The law of mass-action, and the principle of the co-existence of reactions, are thus amply confirmed. But the expressions, reaction-velocity, or velocity-coefficient, or coefficient of velocity, must be analysed.

The ratio $\left(\frac{\xi}{1-\xi}\right)^2$ is called by Ostwald the *partition-coefficient* of the reaction. The square root of this ratio, *i.e.* $\frac{\xi}{1-\xi}$, is the same as the square root of the ratio of the velocity-coefficients of the two parts of the change, *i.e.* it is the same as $\sqrt{\frac{c}{c'}}$; it is also identical with the ratio of the affinity-coefficients, k/k'.

When equivalent masses of one acid and the sodium salt of another acid interact in dilute solution, ξ represents the number of equivalents of the salt which are decomposed, and $1 - \xi$ represents the number of equivalents of the salt which remain unchanged, when equilibrium is established; or, to put the statement in another form, as each equivalent of salt decomposed produces one equivalent of acid and one of base, ξ represents the number of equivalents of base which have combined with the second acid, and $1 - \xi$ represents the number of equivalents of base which have remained in combination with the first acid. The ratio $\frac{\xi}{1-\xi}$ then expresses the distribution of the base between the two acids. In the case of sodium sulphate (Na_2SO_4) reacting with nitric acid ($H_2N_2O_6$), Thomsen found $\xi = \frac{2}{3}$; therefore, the ratio $\frac{\xi}{1-\xi} = \frac{2}{3}/\frac{1}{3} = 2$. In this case, the direct change consists in formation of sodium nitrate and sulphuric acid, and the reverse change consists in the re-formation of sodium sulphate and nitric acid; the square root of the ratio of the velocities of the direct and reverse changes in this reaction is $\frac{2}{3}/\frac{1}{3} = 2$. Or, one may say that the ratio of the affinity-coefficients of the acids nitric and sulphuric for the base soda is $\frac{2}{3}/\frac{1}{3} = 2$. These statements are identical. Two-thirds of the soda combines with the nitric acid, and one-third with the sulphuric acid, when equilibrium is established; or the velocity of the direct change is double that of the reverse change; or the affinity of nitric acid for soda is twice that of sulphuric acid for the same base. It must be remembered that the acids and the base interact in equivalent quantities and in dilute aqueous solution.

Proceeding in the way indicated by the foregoing example, Ostwald determined the ratio $\sqrt{c/c'}$, or k/k', for many acids reacting with a given base; he stated these ratios in terms of one acid taken as 100. For instance, taking the base soda (Na_2O) the ratio for $\frac{H_2Cl_2}{H_2SO_4}$ was found to be 1·94, for $\frac{H_2N_2O_6}{H_2SO_4}$ 2·0, and for $\frac{H_2Cl_2}{H_2N_2O_6}$ ·97. If the affinity of nitric acid for soda is taken as 100, that of hydrochloric acid for the same base, according to these results is 97, and that of sulphuric acid is 50. Ostwald examined many different experimental methods for measuring the distribution of a base between two acids in dilute solution. The experimental difficulties are great, and the results obtained by one method cannot be expected to agree very closely with those obtained by another. Secondary reactions very often complicate the change which it is sought to measure. The order of the affinities of many acids, for a specified base, was not altered by a change of method, except in a few cases: in these cases the affinities were very small, and therefore incapable of accurate measurement by any of the methods tried.

Ostwald next proceeded to examine the influence of the nature of the base on the affinities of acids. He showed that whether the base be potash, soda, ammonia, magnesia, zinc oxide, or copper oxide, the ratio of the affinities of hydrochloric and nitric acids is the same; but that the ratio varies in the case of sulphuric and hydrochloric, or sulphuric and nitric, acids. But it is known that sulphuric acid reacts with its normal sodium salt to form an acid salt ($NaHSO_4$); Ostwald was able to explain the results obtained with sulphuric acid on the supposition that the affinity of this acid for a base, as measured by any of the methods used by him, really represents only the affinity of that part of the acid which has not combined to form an acid salt. He concluded that the true relative affinity of sulphuric acid, like the affinities of hydrochloric and nitric acids, is independent of the nature of the base. Extending the investigation to other acids, Ostwald concluded that the relative affinities of the acids are independent of the nature of the bases with which they react, and can be expressed by constant numbers. If this conclusion is accepted, it follows, from the nature of the reaction examined, that the relative affinities of the bases are also independent of the acids with which they react, and can be expressed by constant numbers. From these conclusions, the further deduction is made that the affinity between an acid and a base is the product of two specific affinity-coefficients, one of which belongs to the acid and the other to the base.

This conclusion is of extreme importance and requires rigorous examination. In order to test the accuracy of the statement that each acid has a specific affinity-coefficient, Ostwald has determined the affinities of a series of acids by different methods, with the result that the affinity-coefficients determined by one method are as nearly the same as those determined by other methods as could be expected, considering the errors inherent in the methods themselves. If each acid possesses a specific affinity-coefficient, the value of this coefficient for any acid might be expected quantitatively to condition many, if not all, the reactions brought about by that acid. Several chemical changes brought about by acids, other than those in which an acid interacts with the salt of another acid, have been examined by Ostwald. Among these changes may be mentioned that of acetamide to ammonia and acetic acid, that of methylic acetate to acetic acid and methylic alcohol, and that of cane-sugar to inverted sugar. The rate of each of these changes varies according to the acid added to the system; the results obtained show that the square roots of the ratios of the velocity-coefficients are in the same order as, and are as nearly identical as could reasonably be expected with, the ratios of the affinity-coefficients of the acids employed, as determined by the division of a base between these acids. Hence the conclusion that each acid has a specific affinity-coefficient is verified, and at the same time new methods for determining these coefficients are put into the hands of chemists.

But none of the methods employed was found altogether satisfactory. In every case secondary reactions more or less interfered with and complicated the primary change.

There is, however, another and altogether different method whereby the affinities of acids may very accurately be determined. This method is based on the relations which certainly exist between the rate of a chemical change brought about by an acid and the electrical conductivity of an aqueous solution of that acid. If the electrical conductivities of dilute aqueous solutions of a number of acids are stated in terms of that acid which has the greatest conductivity taken as unity, and the numbers so obtained are compared with the relative affinities of the same acids determined by one of the methods already described, a very close parallelism is noticed between the two series of numbers. By carefully studying the effect of dilution on the conductivities of monobasic acids, Ostwald has arrived at the conclusion that the dilutions at which the molecular conductivities of monobasic acids exhibit equal values bear a constant relation to each other. For instance, the molecular conductivity of monochloracetic acid at any dilution is equal to that of butyric acid when the solution of the latter is 256 times more dilute than that of the former acid. By *molecular conductivity* of an acid is meant the conductivity of a solution of a quantity of the acid proportional to its molecular weight. If μ = molecular conductivity, and λ = electrical conductivity, as ordinarily defined, stated in mercury units, then $\mu = 10^7 n\lambda$, where n = number of litres to which the molecular weight of the acid taken in grammes is diluted.

The conductivities of the stronger monobasic acids, such as nitric, hydrochloric, chloric, vary but little with dilution; the maximum values are reached in moderately dilute solutions. The conductivities of the weaker acids, such as phosphoric, acetic, butyric, however, vary much with dilution, and increase very considerably as dilution increases. The rate of increase varies; as a rule, the weaker the acid the greater is the increase for a specified dilution. The maximum values are not the same for all acids. Ostwald's investigations show that the affinity of an acid is closely connected not so much with the maximum conductivity of a solution of that acid as with the rate of increase of conductivity relatively to the maximum conductivity. To determine the affinity of an acid, by the electrical method, it is, therefore, necessary to determine the molecular conductivity of an aqueous solution of that acid at varying dilutions until the maximum conductivity is reached.

But it is very difficult, if not impossible, to determine directly the maximum conductivity of a solution of a weak acid, because when very much water is present the unavoidable impurities in the water affect the conductivity more than the minute quantity of acid which is present. Ostwald has found that the maximum conductivity of a monobasic acid in solution can be calculated from determinations of that of the sodium salt of the acid, and moreover that the maximum conductivity of the sodium salt can be calculated from the observed conductivities at different dilutions. The method by which these results are arrived at cannot be gone into here; suffice it to say that it is based on an extension and modification of the generalisation made by Kohlrausch, to the effect that the conductivity of an aqueous solution of a normal salt of a strong monobasic acid is the sum of two constants, one of which depends only on the nature of the acid, and the other only on the nature of the base.

The further application of the electrical method to find the affinity-coefficients of acids rests to a large extent on the extension made by Arrhenius to electrolysis of van 't Hoff's *law of osmotic pressure*. The law asserts that equal volumes of solutions of definite substances, at the same temperature and osmotic pressure, contain equal numbers of molecules, which numbers are the same as would be contained in equal volumes of gases at the same temperature and pressure. The law has been verified in different directions; it cannot, however, be accepted as a final statement. One conclusion drawn from the law of van 't Hoff, by thermodynamical reasoning, is that solutions of definite substances in the same solvent which have the same freezing-point exert equal osmotic pressures at their freezing-points; and hence, solutions which contain equal numbers of molecules in equal volumes, and which therefore exert equal osmotic pressures, have the same freezing-point. This deduction is identical with the *law of molecular lowering of freezing-point*, empirically established by Raoult. This deduction, if granted, enables the osmotic pressures of solutions to be calculated from observations of the freezing-points of these solutions; the calculated pressures can then be compared with those determined by direct experiment. There are many apparent exceptions to the law of molecular lowering of freezing-point, and to the law of van 't Hoff. Arrhenius explains the exceptions by supposing that the substances in question are partially dissociated in aqueous solution, and that therefore a specified volume of one of such solutions contains a greater number of molecules than would be the case if dissociation had not occurred. This explanation rests on the analogy between the gaseous state and the state of substances in dilute solution. As the pressure of the vapour obtained by heating ammonium chloride is greater than that calculated by Avogadro's law on the assumption that the vapour consists of molecules of NH_4Cl, but as the observed pressure agrees with the calculated pressure when the vapour is assumed to consist of equal numbers of molecules of NH_3 and HCl, so the apparently abnormal osmotic pressures of many solutions may be reconciled with the law of Van 't Hoff by assuming that the compounds in these solutions are more or less dissociated into simpler molecules. Substances which are not (by hypothesis) dissociated in aqueous solution are generally, if not always, non-electrolytes. The exceptions to the law of van 't Hoff occur chiefly, if not wholly, among electrolytes. Ostwald, following Arrhenius, supposes such electrolytes to be more or less dissociated into their ions in aqueous solutions.

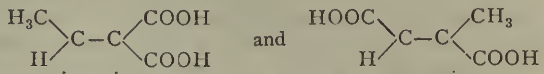
As this hypothesis of electrolytic dissociation rests on the identity of the laws expressing gaseous dissociation and dissociation in solution, it follows that generalisations made regarding gaseous dissociation may be applied to dissociations in solution. Suppose that a gaseous substance is dissociated into two gases; let the pressure of the undissociated portion be p, and the pressure of the dissociated portion be p_1; then, at constant temperature, the relation of p to p_1 is expressed by the equation $\frac{p}{p_1^2} = c$. Again, the pressure of a gas at any specified temperature is proportional to its mass, u, and inversely proportional to its volume, v: now, as the osmotic pressure of an undissociated compound in solution, according to the law of van 't Hoff, is equal to the pressure which the same mass of that compound would exert if it existed as a gas occupying the same volume as is occupied by the solution, the osmotic pressure in the solution, p, may be put as proportional to $\frac{u}{v}$; therefore, from the equation already given, $\frac{uv}{u_1^2} = \text{C}$.

Let μ_∞ = molecular conductivity of a binary electrolyte at infinite dilution, and let μ_v = conductivity of v litres containing one molecular weight in grammes of the electrolyte; then, the fraction μ_v/μ_∞ expresses the molecular conductivity at any stated dilution referred to the maximum conductivity, and on the hypothesis of electrolytic dissociation the same fraction expresses the portion of the electrolyte which is dissociated in terms of the whole quantity of the electrolyte taken as unity. If this fraction is expressed by u_1, and if u represents the undissociated portion of the electrolyte, we have $u = 1 - \mu_v/\mu_\infty$. If now we put $m = \frac{\mu_v}{\mu_\infty}$, and substitute in the equation $uv/u_1^2 = \text{C}$, we have $\frac{1 - m}{m^2}v = \text{C}$. This equation states that $\frac{1 - m}{m^2}v$ must have the same value for all dilutions of any one binary electrolyte; a statement which is amply confirmed by the researches of Ostwald. The constant C obtained by applying the above equation to a monobasic acid represents the affinity of that acid. The constant C measures the readiness of an aqueous solution of the acid to conduct electricity, as also its readiness to take part in chemical reactions; the value of C depends only on the nature of the acid, and is independent of dilution. As C has small values for strong acids and large values for weak acids, Ostwald prefers to put the equation in the form $\frac{m^2}{(1-m)v} = k$, where $k = \frac{1}{C}$. To avoid small fractions Ostwald multiplies m, and also k, by 100; he has determined $100k$ for more than 100 monobasic acids at dilutions varying from 8 to 1024 litres; finally, he expresses the most probable value of $100k$ as K. I cannot here give even a selection from the numerous measurements of K made by Ostwald, but must content myself with drawing attention to some of the conclusions he has come to regarding connexions between the affinities and the constitution of acids. The method has been worked out chiefly for monobasic acids.

In the acetic series of acids, affinity decreases from formic to propionic acid, and then remains nearly constant until caproic acid is reached. The substitution of chlorine or bromine for hydrogen in an acetic acid raises the affinity, bromine causing a smaller increase than chlorine. If S is substituted for O in the group COOH in acetic acid, the value of K is raised from ·0018 to ·0469; while the substitution of the group SH for H in the same acid is attended with an increase in the value of K from ·0018 to ·0225 only. The greater or less acidic character of such groups as OH, OCH_3, OC_6H_5, NO_2, &c., is quantitatively measured by the increase in the value of K attending the substitution of one of these groups for H in an acid. In the acetic acids, the change of H to OH is accompanied by an increase of affinity, OCH_3 is more acidic than OH, and OC_6H_5 is the most acidic of the three radicles considered. In studying the relations between the affinities of acids and their derivatives, attention must be paid not only to the composition and character of the replacing groups, and to the series of acids in which the replacement occurs, but also to the position of the replacing groups relatively to the other atoms of the molecules. The influence of position is very marked in the affinities of the isomeric oxy, chloro, nitro, methoxy, and acetoxy, benzoic acids. The following numbers exhibit the influence of the positions of the replacing groups:—

		K.
C_6H_3 . COOH . OH . OH	1 : 2 : 3	·114
,, ,,	1 : 2 : 6	5·0
C_6H_5 . COOH		·006
meta—C_6H_4Cl . COOH		·0155
ortho— ,, ,, ...		·132
meta—$C_6H_4NO_2$. COOH		·0345
ortho— ,, ,, ...		·616
ortho—C_6H_4 . OC_2H_3O . COOH ...		·0333
para— ,, ,, ,, ...		·00422
ortho—C_6H_4 . OCH_3 . COOH ...		·00815
para— ,, ,, ,, ...		·00302

It is seen that the group OCH_3, or OC_2H_3O, substituted for H in benzoic acid, raises the affinity, if the group is placed in the ortho-position, but decreases the affinity if the group is placed in the para-position. The influence of the position of the replacing groups on the change of affinity of many acids points to some connexion between the affinities of acids and the space-arrangement of the atoms which form the molecules of the acids; measurements of the affinities of such acids as maleic and fumaric, mesaconic, citraconic, and itaconic, confirm this conclusion. Maleic acid is about twelve times stronger than fumaric acid; these acids are probably geometrically isomeric, and the COOH groups are probably nearer one another in maleic than in fumaric acid. Again, if the formulæ of Wislicenus for citraconic and mesaconic acids are adopted we should expect the former to be the stronger of the two. These formulæ represent the acids as geometrically isomeric; they are—



citraconic mesaconic

The values obtained for K are, for citraconic ·34, for mesaconic ·079: the third isomeride, itaconic, is very weak; K = ·012.

Ostwald's researches open up a new path along which advance may be made: they show us how to connect the characteristic property of an acid, its affinity, with the constitution of the acid; they form a further and more important step towards solving *the* problem of chemistry, which is to find definite and measurable connexions between the properties and the composition of homogeneous kinds of matter.

But the coefficient of affinity of an acid has not yet been fully analysed. What is the meaning of the constant K? What is affinity? The value of K for a monobasic acid measures the readiness of that acid in solution to take part in chemical changes, and also the readiness of an aqueous solution of that acid to conduct electricity. Now, when a compound is electrolysed, the parts or ions into which it is separated are chemically equivalent and carry with them equal quantities of electricity, and the electricity travels only with the ions. The conductivity of the electrolyte will depend on the number of molecules electrolysed, and on the velocity of transference of the ions across the space separating the electrodes. The greater the number of molecules separated into ions, and the more rapid the migrations of these ions, the greater will be the conductivity of the substance. Hence the value of K for an acid will be conditioned by the amount of separation into ions, and the rate of migration of these ions; *i.e.* the affinity, as well as the conductivity, of the acid will depend on these quantities. The ions into which a monobasic acid is separated when electrolysis occurs are H and a negative radicle; the scheme of electrolysis may be represented as HR = H + R. As hydrogen moves much more rapidly than the most rapid negative acidic ion, the molecular conductivity of a monobasic acid in solution is chiefly conditioned by the degree in which the acid is separated into its ions. The affinity of the acid is sometimes dependent to a considerable extent on the velocity of the negative ion: in such cases acids which are separated into their ions to an equal extent will exhibit different affinities; in other cases the degree of electrolytic separation is the chief factor conditioning the affinity. Now the fact that, so far as accurate research has gone, electrolytes fully obey Ohm's law, or, in other words, the fact that the smallest electromotive force suffices to cause electrolysis, points to the action of the E.M.F. in electrolysis as being only a directive action on the ions already existing. This view of electrolysis has been developed by Clausius, and recently by Arrhenius, van 't Hoff, and Ostwald. The hypothesis, in its present form, bids us regard an aqueous solution of an electrolyte as already more or less completely dissociated; it bids us see the molecules of the electrolyte in the solution as dissociated into their ions; it says that the electrolytic and the chemical activity of the solution is dependent on the ratio between the number of dissociated, or "active," molecules, and the number of undissociated, or "inactive," molecules. This view of electrolysis, and of chemical change occurring between electrolytes, regards an aqueous solution of a strong acid as containing a great many free ions, which are, respectively, hydrogen and a negative radicle; it looks on an aqueous solution of a weak acid as containing only a few free ions.

There are difficulties in the way of accepting the hypothesis of electrolytic dissociation. At first sight one is shocked by being told that a very strong acid such as nitric acid, or a very strong base such as potash, is dissociated in aqueous solution, to perhaps 90 per cent., into its ions; in the case of potash, one remarks that the ions must be potassium and the group OH, and that each of these bodies reacts with water the moment they are brought into contact. To meet these objections, Ostwald reminds us that a chemically energetic compound is one which readily suffers chemical change, and the parts of which are therefore readily separated; and he remarks that the *ion* potassium is not the same thing as ordinary potassium; the ion holds a large electric charge; when it comes to the electrode it gives up this charge, and *then*, but not till then, it reacts with water. But difficulties still remain: one of the greatest is to explain the mode of action of the solvent. Does the solvent merely form a medium in which the separate ions move about? Why then does increase of solvent increase the amount of dissociation? May not the solvent react with the dissolved body to form complex molecular aggregates which then dissociate into simpler ions? Is the dissolved body the electrolyte, or is the electrolyte a compound, or aggregate, made up of the dissolved body and the solvent? Is the electrolyte actually separated into its ions in the solution, or does it only exhibit an "aptitude for directed dissociation"? These questions, and questions such as these, have yet to be answered.

The hypothesis of electrolytic dissociation has been worked out in detail in several directions, by Arrhenius and Ostwald, and has been found to give results in keeping with experiment. In considering its application to explain chemical change between electrolytes—for it really presents a theory of chemical changes between electrolytes—it is necessary to remember that, in its present form at any rate, it is applicable only to substances in aqueous solution. Because a solution of hydrochloric acid is very chemically active, it does not follow that liquid HCl should also be chemically energetic; nor, because gaseous HCl is not dissociated by heating to a fairly high temperature, does it follow that an aqueous solution of this compound should not be largely dissociated into the ions hydrogen and chlorine.

The hypothesis of chemical change between electrolytes in solution, which is based on van 't Hoff's extension of the law of Avogadro to substances in dilute solutions, and on the general close agreement between such dilute solutions and gases, cannot yet be finally accepted or rejected by chemists. It has already done much to draw closer the connexions between chemical and electrical phenomena, it has gone further than any other hypothesis of chemical change in helping forward the solution of the main problem of chemists, and it has opened up many new lines of advance.

There is one general conclusion to be come to from the study of all the recent work on chemical affinity: I think we may agree with Ostwald when he says that Bergmann was certainly right in assigning a definite affinity to each element and compound, and that Berthollet was right in asserting that affinity is modified by the relative masses of the reacting bodies, but that Bergmann erred in saying that chemical change always occurs in one direction only and that the direction of the strongest affinities, while Berthollet also erred in regarding the affinity between acids and bases as inversely proportional to the equivalent weights of the reacting compounds. Bergmann's error has been revived in modern times; it has now assumed a physico-chemical aspect; it finds its expression in Berthelot's so-called *law of maximum work*, which asserts that every chemical change accomplished without the addition of energy from without tends to the formation of that body or system of bodies the production of which is accompanied by the development of the maximum quantity of heat. In so far as this statement can be translated into precise terms it can be proved to be dynamically unsound. When applied to chemical reactions, it tells us that of several possible reactions that one which is accompanied by the production of the greatest quantity of heat occurs to the exclusion of others; but this has again and again been experimentally disproved.

M. M. PATTISON MUIR.

THE PASTEUR INSTITUTE.

LAST week the Lord Mayor received a letter from M. Pasteur, acknowledging receipt of the resolutions passed at the recent Mansion House meeting. In this letter M. Pasteur writes:—

"If the aphorism that science has no country has never received authoritative sanction, it did so at this meeting, in which the leading *savants* in biological and medical science of the United Kingdom took part. I wish I could thank them individually for having attended this gathering. I was filled with gratitude on learning that the Prince of Wales himself had accorded his high approbation of your initiative. Modesty compels me to pass over in silence the kind words of which my labours and those of the Pasteur Institute have been the subject, but I have a right to rejoice with all friends of the progress of humanity at the great moral effect of the meeting. The manifestation of July 1 had not only for its object the question of the treatment and possible extinction of hydrophobia in England, but in the nature of things it was also a protest against that false sentimentality which led certain persons, not—which was already a strong point with them—merely to put on the same footing the life of men and that of animals, but even to prefer the existence of animals to the salvation of human life. When this view is taken, what is the limit? We must become firm vegetarians. We must even extend our scruples so that no living being is sacrificed. We must endure the importunities of a mosquito, the daring of a mouse, the stings of a flea—false ideas or excuses for a tirade which one finds is most often at the bottom of all the attacks on experimental physiology. Certain credulous souls—by I know not what tales—imagine that our laboratories are chambers of torture. They ignore the fact that the rabbit or the guinea-pig is rendered insensible by chloroform before it is subjected to the most insignificant operation. As for me personally, the suffering of an animal affects me so much that I would never shoot a bird, and the cry of a wounded skylark pierces me to the heart; but if the investigation of the mysteries of Nature and the acquisition of new truths be at stake, the sovereignty of the object justifies all. Who, then, having the least regard for the pursuit of the knowledge of the mysteries of Nature, would put in the balance the sacrifice of a few fowls and rabbits with the discovery of the attenuation of virus and prophylactics which have resulted from such sacrifice? No one, my Lord Mayor, will have contributed more than you have done to rectify the errors which under a show of compassion can only hinder the progress of science and compromise even the most legitimate interests of humanity."

THE TERRESTRIAL GLOBE AT THE PARIS EXHIBITION.

SOME time before the opening of the Paris Exhibition it was announced that one of the attractions of the show would be a great terrestrial globe, one millionth of the actual size of the earth. This globe is now exhibited in a building specially erected, near the Eiffel Tower, for the purpose, and it excites the warmest interest among all visitors who have devoted the slightest attention to geographical science. It was designed by MM. Villard and Cotard, and these gentlemen, who have received many congratulations on their success, have lately issued an account of the manner in which their project has been realized.

Maps on a plane surface give, of cause, a very inadequate impression of the real appearance of our planet; and ordinary globes are too small to indicate, even vaguely, the extent of the spaces represented on them. The idea of making a globe one millionth of the size of the earth deserves, therefore, to be described as a "happy thought," for, although the meaning of a million may not be fully appreciated, it is not absolutely inaccessible to the human mind. When we see a place or a district marked on a globe, and learn that the reality is a million times larger, the proportions are impressively suggested, with at least some approach to accuracy.

The diameter of the globe constructed by MM. Villard and Cotard is 12·73 metres. It has a circumference of 40 metres, and a millimetre of its surface represents a kilometre. The globe consists of an iron framework made chiefly of meridians united to a central core. This structure is carried by a pivot resting on an iron support. To the meridians pieces of wood are attached, and on these are fixed the panels composing the surface of the globe. These panels are made of sheets of cardboard bent by hand to the required spherical shape, and covered with plaster specially hardened. Fig. 1[1] shows how they are applied to the underlying structure. The total surface

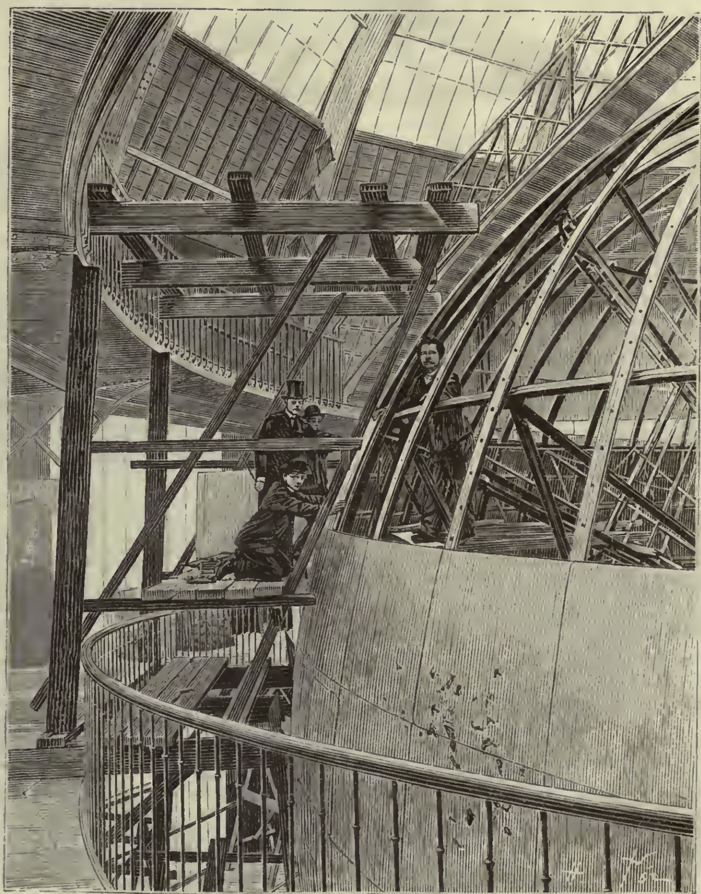


Fig. 1.

is divided into forty spindle-shaped spaces, the breadth of each of which at the equator is exactly one metre. Each "spindle" is itself subdivided, so that there are 600 panels of various dimensions. The designs are painted on the panels before they are put in their place, in order that the globe may ultimately be easily dismantled and removed.

The edifice in which the globe is shown has a metallic framework forming a cupola. It is lighted from above, and by the great glass frames of the sides. From a terrace or narrow foot-bridge at the upper part the visitor can see the polar and temperate regions of the northern hemisphere. As he descends, he is able to see in succession all the regions of the globe to the south pole. At the bottom he comes to the support of the globe with the apparatus for putting it in motion (Fig. 2).

Even the loftiest mountains, if shown in relief, could only have been represented by elevations a few millimetres in height. Consequently the various mountain ranges have been painted on the surface. The various depths of the ocean are indicated in a similar manner.

To facilitate the study of the globe, it has been mounted with its axis vertical, and it may be turned upon the pivot which carries it. If its rotation were made to equal that of the earth, at its equator, a point of its surface would move at the rate of half a millimetre in the second. This

[1] We are indebted to the editor of *La Nature* for the figures here reproduced.

movement would scarcely be visible, but it would, of course, represent an actual movement of the earth over half a kilometre in the same time.

A figure of the moon, corresponding to this one of the earth, would have a diameter of 3·50 metres, and would be 384 metres distant. A like figure of the sun would have a diameter of 1400 metres, and be distant about 150 kilometres. The diameter of a globe representing Jupiter on the same scale would be one-half, that of a globe representing Saturn on the same scale would be a little more than one-third, of the height of the Eiffel Tower.

Fig. 2.

This is not the first occasion on which an attempt has been made to suggest by means of a great globe the size of the earth, and the extent of its oceans and land-masses. The globe of the Château of Marly, which is still to be seen in the National Library of Paris, excited much admiration in the age of Louis XIV., but it has only a diameter of about 5 metres, and is much less effective for its purpose than its successor in the Paris Exhibition.

It is significant of the present stage of our knowledge of the interior of Africa that the makers of the globe, in preparing their maps, had twice to alter their representation of that continent in order to indicate the results of the most recent geographical discoveries.

MARINE BIOLOGY IN THE UNITED STATES.

THERE has recently been issued the first Annual Report of the Marine Biological Laboratory at Wood's Holl, Mass. The Laboratory is an outgrowth of a smaller predecessor maintained at Annisquam, Mass., for six years, by the Woman's Education Association of Boston, in co-operation with the Boston Society of Natural History; and the locality where it is pitched is one which has been in especial favour with marine zoologists of the New World, from Alex. Agassiz downwards. The edifice is a small one (63 × 28 feet), two stories high, of plain but very substantial build. It has been especially designed for the purpose to which it is put, and there are eight private rooms available for the use of investigators. Conspicuous among the names of those chiefly concerned in its maintenance are those of persons known to be familiar with the workings of the leading biological laboratories abroad; and Dr. C. O. Whitman, of Milwaukee, has accepted the office of Honorary Director. It is thus manifest that, in the selection of those who are to control the working of their enterprise, the promoters have secured the services of those of their countrymen whose influence would be most conducive to a successful issue.

The Laboratory is regarded by the Director as a "first step towards the establishment of an ideal biological station, organized on a basis broad enough to represent all important features of the several types of laboratories hitherto known in Europe and America." In a very interesting opening address, the same gentleman lays it down as a tenet that "a biological station should be a purely scientific affair from beginning to end," and the spirit of his words appears to have entered into the very organization of the institution over which he presides. Competent investigators not requiring instruction are invited to carry on their researches free of charge, and a small fee is asked only of those whose work requires supervision; while, with a view to developing the resources of the country, provision is made for the conducting of short seven weeks' courses of instruction in marine zoology and microscopical technique. Arrangements are also to be made for the delivery of "occasional lectures, or informal accounts of results obtained in special lines of research carried on at the Laboratory."

The above-named short courses of instruction are no mere vacation ones, whereby the Laboratory would be in danger of conversion into a summer *rendezvous*, but recognized portions of a working scheme; and, in providing for them, our American brethren have taken a new and most important departure in the advance of biological education, and one upon which we ourselves might well act. To many of us it has long been obvious that our own methods of teaching elementary biology are being overstrained. The type-system, in which we justly glory, is being pushed to an extreme not dreamt of by its founders; but while some such method must always be relied upon for a first beginning, we stand in need of a supplementary system, whereby there may be assured to the advanced student a field of labour less restricted than that now largely adopted. We would have him brought face to face with unfamiliar forms of life—forms of which he might probably never have heard—and left to himself (competent assistance being accessible in case of emergency) to identify and to determine them. The student is, at present, nurtured on too great a regard for authority; he is taught to rely too fully upon his teacher, and his powers of independent judgment become thereby stunted; and, unless some means be taken to dispel this delusion, the systematic work of even the near future must suffer. We are of opinion that the remedy is to be found in some such action as that instituted by the officers of the Wood's Holl Laboratory. We need more field-work, and the advanced student should be compelled to supplement the special training which he now receives with, say, a two to three months' course at the sea-side. Many of our existing schools are already located in situations favourable to the requirements of the case, but their movements are so hampered by the demands of the narrow "syllabus" that little opportunity is left them for the development of their special resources. Setting these institutions aside, however, we believe that access to a fully equipped laboratory is not a *sine quâ non* for the fulfilment of that which we desire. It is true that "any enthusiastic young person who may unfold his umbrella on the sea-shore" cannot be said to have "opened a zoological station"; but it is none the less certain that a born biologist will pursue his calling even under a sunshade, and it should be one of the highest aims of our educational system to single him out. To this end, let the student found his own laboratory in a convenient room in some good locality; set him to collect, to identify, and to preserve; let him rely upon his ingenuity for the construction and arrangement of his accessories; give him ample opportunity to make the most of the resources of the surface-net; and leave the rest to nature. The student who, granted a previous sound elementary training, free of bias, would most readily rise to the emergencies of the case we picture, would be he to whom we would most confidently intrust the future development of our science; and it cannot be denied that our existing methods of training fall short as a sure means of securing him.

Our American brethren are content with humble beginnings. Their Laboratory is small, but it is managed as such an institution should be. We believe our dream to be indicative of a general want; and, should its realization ever come about, to the women of the United States will be due the honour of having inaugurated a recognized system of training such as, to us, seems most desirable for its attainment. Better this than empty glory in a costly edifice.

Young as is the Wood's Holl Laboratory, a record is published, without ostentation, of work commenced in five definite subjects, and efforts are being made to establish a scholarship fund in connection with the institution. The citizens of the United States are now striving by private enterprise to do, for the pure science of aquatic biology, that which their legislators have so nobly done for the fish industries. We heartily wish them success.

G. B. H.

NOTES.

THE next International Archæological Congress is to be held in Christiania in 1891. It was originally intended that it should be held in London. Dr. Ingvald Undseth, of Christiania, is the General Secretary.

MORE than 500 members will take part in the forthcoming Oriental Congress in Stockholm, among them being official delegates from Egypt, Persia, India, Siam, China, and Japan. Two famous Arabic scholars of Medina—Mahomed Mahmud and Mahomed Chingîtbî—will also be present.

THE programme of the second summer meeting of University Extension students and others, to be held in Oxford next month, is now published. The programme, as compared with last year's, shows one remarkable difference. The summer meeting of this year is to be divided into two parts, the first of which, lasting from Tuesday, July 30, to Friday, August 9, reproduces the main features of the meeting of last year—meetings, *conversaziones*, excursions, lectures and visits to libraries, museums, and so forth. On the list of lecturers appear the names of Prof. Max Müller, Sir Robert Ball, Mr. Herkomer, Mr. Lewis Morris, Prof. Henry Morley, Mr. W. J. Courthope, Mrs. Fawcett, Prof. Thorold Rogers, Prof. Pritchard, Prof. A. H. Green, Prof. S. R. Gardiner, Mr. Arthur Sidgwick, Mr. R. G. Moulton, and many others. The second part of the meeting, which is the special feature and new departure of this year, is to begin on Saturday morning, August 10, and end on Friday evening, August 30. This is intended to be a period of more serious and sustained study and instruction for those whose leisure and industry have not been exhausted during the previous ten days, as well as for those who may prefer three weeks of more quiet and systematic reading and lecturing. The lectures in this second part are arranged in connection with lectures of a more general character delivered in the first part. It is estimated that the total expense of attending the first part of the meeting need not exceed £5 for each person (including railway fare and price of ticket), and may be considerably less if several persons live together; while £10, it is estimated, may cover the expense of attending both parts of the meeting. The Secretary is Mr. W. A. S. Hewins, 35 Cornmarket Street, Oxford. The number of tickets is limited to 1200, of which about five-sixths have been already applied for.

Sir Edward Watkin was the client for whom Mr. Perks bought the summit of Snowdon at Tokenhouse Yard last week. It is said that Sir Edward has intimated his intention of offering a site on the summit to the Royal Astronomical Society for purposes of an observatory similar to that on Ben Nevis.

On Monday a deep-sea exploration party started from Kiel, on board the steamer *National*, for the Greenland coast, where they propose to carry on a series of submarine soundings and investigations. The expedition is directed by Prof. Hensen.

According to the *Times of India*, Mr. Oldham, of the Geological Survey of India, who is at Simla at present, is to be deputed to Mergui, in Burmah, on geological work.

Mr. Elliot, head of the Meteorological Department, has, according to the *Times of India*, reached Simla after a long and useful tour. He has arranged for the publication of a map of Bombay, showing the daily state of the weather on the coast, similar to that issued in Calcutta.

The vexed and protracted question of a good zoological collection for Bombay is, after years of discussion, at last on the point of being settled. It came to the ears of the Governor, Lord Reay, that the terms on which the Victoria Gardens are held by the Municipality of Bombay were at the bottom of the whole difficulty. No charge for admission could be levied at any time without the express consent of the Government. But without the aid of fees it would be impossible to maintain, much less to establish, a really good collection. The Government thereupon intimated their willingness to see a moderate fee charged for admission on certain days in the week, and on June 17 the matter was brought before the Corporation, and the proposals of the Municipal Commissioner were accepted. Curiously enough, the *Times of India*, which brings this information, also contains a letter from Mr. H. B. Brady, F.R.S., from London, describing the present zoological collection of Bombay as "a few poor beasts wretchedly housed." But now that fees can be charged at the Victoria Gardens, the situation is entirely changed, and there is no reason why the Bombay zoological collection should not speedily equal the fine collection at Calcutta.

Dr. Francis Day died on July 10 at his residence, Kenilworth House, Cheltenham. He was appointed to the Madras Establishment in 1852, and after taking part in the military operations then in progress at Burmah, for which he received the medal, he devoted himself exclusively to the study of fishes, and became Inspector-General of Fisheries in India. The results of his labours he presented in reports to the Government of India of 1865 to 1877, in numerous papers to scientific journals, and in the following general publications:—"The Fishes of Malabar," 1865; "The Fishes of India," 1868; "The Fishes of the Andaman and Nicobar Islands," &c., 1870; "The Fresh-water Fish and Fisheries of India and Burmah," 1873; "The Fishes of India," second edition, 1875-79; and "The Fishes of the Nilghiri Hills and the Wynaad," 1876. The Imperial Museum at Calcutta possesses his type collection of Indian fishes; and collections formed by him are in the Natural History Museums at Leyden, Berlin, Florence, and Sydney, and in the British Museum, to which he also sent his collection of Indian crabs. Dr. Day retired from the Madras Medical Staff in 1877. He then began the study of the fishes and fisheries of the United Kingdom, and in 1880-83 published "The Fishes of Great Britain and Ireland." He was created a Companion of the Order of the Indian Empire in 1885, and about the same time received the cross of the Order of the Crown of Italy.

According to the *Colonies and India*, the Dunedin Acclimatization Society have solved one of the greatest problems in connection with the acclimatization of salmon. They have procured ova from fish reared from ova sent from this country. It is claimed that this has never before been done in any part of the world.

In connection with a note by M. Leroy, in the *Comptes rendus* of June 17, M. Landerer pointed out, in a note read at the meeting of the Paris Academy of Sciences on July 8, that he was the first to describe the phenomenon of the decomposition of the image of the horizontal lines seen with the eye which remains closed during microscopic observations. M. Landerer offered two remarks in addition to his former statements: (1) although the effort made by the eye in microscopic vision appears to be of the same nature as the effort demanded by telescopic vision, the trouble caused to the closed eye is much more sensible in the former case than in the latter, no matter what the telescopic object may be. (2) The disposition which must be given to the eyes during microscopic vision involves the crossing of their optical axes, producing an effect like that of "strabism." This is proved by the fact that, in giving them this disposition, and then applying the eye to the ocular, one perceives the image distinctly. It is this simultaneous work of the two eyes that explains the trouble experienced by the eye which does not take part directly in the act of vision.

The Reale Istituto Lombardo proposes as subject for the Cagnola Prize (2500 lire, and medal 500 lire) in 1889-90 ("ordinary" competition) the following:—Investigation of one of the (at present few) trisubstituted derivatives of benzol; their mutual relations, and relations to the bisubstituted derivatives to be studied, and facts ascertained which will throw light on the laws of their properties and constitution. Samples of new bodies to be furnished. The date is April 30, 1890. For the "extraordinary" competition (same value of prize), a physico-physiological monograph on one of the larger Lombardy lakes is invited. The research must be carried out according to the directions published by Prof. Forel, of Lausanne, in 1887. Date May 1, 1890. Thirdly, a similar prize is offered for discoveries on the cure of pellagra; or the nature of miasma and contagion; or the steering of balloons; or means of preventing the falsification of writing. Date December 31, 1889. Manuscripts (in French, Italian, or Latin) are to be sent, with sealed letter, to the Secretary of the Institute in Milan.

The Transvaal Volksraad is reported to have placed £20,000 on the estimates for the current year, for the purpose of endowing the first University of the Republic.

According to the Calcutta Correspondent of the *Times*, a herd of 100 wild elephants has been captured in Mysore by

Superintendent Sanderson. The same correspondent states that there were 6000 deaths by snake-bites in the North-West Provinces last year. In Madras, 10,096 cattle were killed by wild animals, and the loss of human life by snakes and wild animals was 1642.

In a telegram from Tashkend, dated July 12, it is stated that a shock of earthquake had occurred at Djarkend, in the Government of Semiretchinsk, by which half the town was destroyed.

Prof. W. Förster, Director of the Berlin Observatory, states in the *Reichsanzeiger* that shortly before midnight on the 11th inst., undulatory motions were observed in two water balances pointing north and south in the Berlin Observatory. These motions, he believes, were a distant effect of the earthquake near Tashkend. Similar motions were observed in Berlin, Breslau, and Königsberg on August 2, 1885, and it is concluded that they were caused by an earthquake which, as was afterwards found, had taken place at Tashkend half an hour earlier.

A slight shock of earthquake was felt at Charleston, U.S.A., at 9 47 on the evening of July 11. The disturbance lasted three seconds, and was accompanied by slight subterranean rumblings. The direction was from north to south.

At a recent meeting of the German Meteorological Society in Berlin, Dr. Lang, of Munich, read a paper on the velocity of propagation of thunderstorms in South Germany in the ten years 1879–88. This is, on an average, 38·4 kilometres per hour; but it has varied considerably from year to year, increasing in the years to 1884, and thereafter decreasing. To this corresponds a curious variation of van Bebber's fourth and fifth depression-paths: which lay in the north at the beginning of the period, then moved south to South Germany till 1884, after which they retired northwards. Hail frequency has varied in an opposite sense to the velocity; but the rapidly moving winter thunderstorms have most hail. The velocity is maximum in winter; it falls rapidly till May, slowly rising thereafter (with a second depression in September) till winter. The velocity is greatest in storms coming from the west. Dividing the region into four zones from north to south, there is a decrease in the velocity, at first slight, but getting very rapid on reaching the Alpine region. The velocity is greatest about midnight, least about midday. At the same meeting, thunderstorms and hail in Bavaria in 1880–88 were the subject of a paper by Dr. Horn. These phenomena in general correspond; both have a maximum early in July, but the hail has a second maximum, nearly as great, in May. Both phenomena show a pronounced day maximum about 3 to 4 (in winter about 2 to 3), and a minimum in the morning from 7 to 8. Dr. Horn said hail never fell in Bavaria without electric discharge, but Dr. Assmann maintained it did sometimes in Prussia.

We have received from Mr. A. L. Rotch the observations made at the Blue Hill Meteorological Observatory in the year 1887. This Observatory, which was established in 1885, is now one of the best-equipped stations in the United States; it is situated in Norfolk County, Massachusetts, about 635 feet above the level of the sea, being the highest point within ten miles of the Atlantic coast from Maine to Florida, and commands an unbroken view of the horizon in every direction. The value of the station has been recognized by the Harvard College, and the present volume appears as vol. xx. Part 1, of the Annals of the Astronomical Observatory of that institution, which is about twelve miles distant. Arrangements have been made for the continuation of this new form of publication, and the ultimate consolidation of the two institutions is contemplated—a step that will insure a more complete discussion of the observations than has been possible hitherto. In addition to monthly summaries, the present volume contains hourly values of all the principal elements. The hourly observations of rainfall, cloud, (7h. a.m. to 11h. p.m.), and sunshine are especially valuable. The sunshine observations are given in a novel and convenient form, showing the amount, in tenths, for each hour. The appendixes contain interesting discussions on thermometer screens, and on the differences of temperature between the base and the summit, as well as tracings from the self-recording instruments illustrating special meteorological phenomena. We congratulate Mr. Rotch and his staff on the completeness of their valuable work.

Amongst the many beneficial measures which have taken place in Mexico, during President Diaz's four years' administration, Sir Francis Denys, of the British Legation, Mexico, in his last report, mentions those for the study and preservation of ancient monuments and historical remains. An inspector has been appointed, the building for the National Museum improved, and various collections relating to natural history, as well as to archæology, have been added. An archæological map of the Republic has been made, and plans and photographs of the palaces of Mitla have been obtained. Explorations of the ruins of Xochicalco, and of the pyramids of Teotibuacan have been undertaken, many interesting discoveries rewarding the explorers of the latter. A wall, 360 metres long, 3 metres high, and 1 metre broad, has been constructed around the palaces of Mitla for the protection of these gigantic monuments. The Republic now possesses a fine public library, where ancient documents and a large collection of scientific and historical works are at the disposal of the student.

About fifty objects of various kinds from the early Iron Age—swords, axes, arrow-heads, &c.—have lately been excavated from a barrow at Hvideseid, in South-Eastern Norway.

An ancient canoe, hollowed by fire from the trunk of a tree, has been discovered in a moss at Thorsager ("Thor's Field") in Jutland, 4 feet below the surface.

In the Report, just issued, of the trustees of the South African Museum for the year 1888, reference is made to the unwelcome appearance in some number, in the entomological collections, of a pest very prevalent in Europe and elsewhere, but hitherto of comparatively rare occurrence in South Africa, viz. the minute neuropterous insects belonging to the genus *Psocus*, and commonly known to collectors as "mites." It is not improbable that the unusually wet weather of the latter half of the year favoured the multiplication of these destructive insects. Naphthaline has been found very serviceable as a check to their attacks.

We notice the appearance of the second volume of the "Ornitographia Rossica," by Th. Pleske, published by the Russian Academy of Sciences. It contains a description of the *Sylviæ* of the Russian Empire. A new edition of N. Kaufman's "Flora of the Government of Moscow," has also been issued. This remarkable work, which is regarded as classical by Russian botanists, was out of print. It has been thoroughly revised, and may be considered the most trustworthy source of information as to the flora of Moscow and the central plateau of Russia.

The third volume of the "Ethnography of the Caucasus," now being published at Tiflis, contains the researches of Baron Uslar relating to the Avarian language. This language is spread in Daghestan, over a territory which crosses the highlands from north to south, and separates the eastern group of the Daghestan languages from the western. It is used by most tribes of the highlands in their mutual relations. Although possessing in its alphabet a great number of consonants hardly distinguishable from one another by the untrained ear, it is said to be very agreeable on account of the excellent proportions between the consonants and the vowels in its words.

A FULL bibliography of Russian books and papers on mathematics and physical sciences since the earliest days of printing is being published at Moscow, by V. V. Bobynin. The first instalment of the second volume brings the work down to the year 1774.

IN the new number of *Harvard College Bulletin* Mr. W. H. Tillinghurst has the following note:—"It is believed that M. Chevreul reached a greater age than any other person who had received a degree from Harvard College, outliving by a year Judge Timothy Farrar (1767), born July 11, 1747, died February 21, 1849, at the age of 101 years, 7 months, 10 days, who received the degree of LL.D. in 1847 on the completion of his one hundredth year. Two graduates of American Colleges have outlived M. Chevreul. Rev. John Sawyer (Dartmouth, 1785), was born October 9, 1755, and died October 14, 1858, aged 103 years, 5 days. He received the degree of D.D. from Dartmouth in 1857, when 102 years of age. But the oldest College graduate in this country known to the writer was Nathan Birdseye (Yale, 1736), who was born August 19, 1714, and died January 28, 1818, aged 103 years, 5 months, 9 days."

SOME interesting facts concerning the "element" tellurium have been brought to light by Dr. Brauner, of Prague, during the course of a series of atomic weight determinations, an account of which is given in the July number of the Journal of the Chemical Society. A determination of the atomic weight of tellurium made by Berzelius in 1832 yielded the number 128·3, and a later one in 1857, by von Hauer, gave the value 127·9. Hence 128 has usually been accepted as the true atomic weight. The properties of tellurium, however, indicate that it belongs to the sulphur group of elements, and that its position in the periodic system lies between that of antimony, of atomic weight 120, and iodine, of atomic weight 127. But according to the above determinations the atomic weight of tellurium is higher than that of iodine. Hence we are obliged to admit one of two things: either that the atomic weight of pure elementary tellurium has been incorrectly determined, or that the periodic law of the elements, that grand natural generalization whose distinguished elaborator English chemists have recently been delighting to honour, breaks down in this particular case. In view of the overwhelming mass of experimental evidence which has now accumulated in support of this generalization, the latter assumption cannot for a moment be tolerated. The redetermination of Dr. Brauner becomes therefore of primary importance, and his results partake of the highest interest. The mode of procedure which afforded the most satisfactory results consisted in the analysis of tellurium tetrabromide, $TeBr_4$, purified in the most complete manner, by means of silver nitrate prepared from pure silver. The mean atomic weight from these experiments was found to be 127·61, the maximum being 127·63, and the minimum 127·59. Hence there can no longer be any doubt that the substance we term tellurium does possess a combining weight larger than that of iodine. Now comes the question: Is this substance pure elementary tellurium? If it is, then, as Dr. Brauner says, it is "the first element the properties of which are *not* a function of its atomic weight." Dr. Brauner, however, finds as the result of a process of fractionation that it is not pure tellurium, and that it consists of probably three elements, pure tellurium mixed with smaller quantities of two other elements of higher atomic weights; and he is at present engaged in studying the nature of these foreign substances, and in the endeavour to isolate pure tellurium itself. A few of the as yet unpublished results obtained in these latter researches were communicated personally by Dr. Brauner at the meeting of the Chemical Society on June 6, and among them the interesting fact was stated that one of the new elements is probably identical with Prof. Mendeleeff's recently predicted dwitellurium, of atomic weight 214, the other new constituent being an element closely allied to arsenic and antimony.

THE additions to the Zoological Society's Gardens during the past week include a Poë Honey-eater (*Prosthemadera novæ-zealandiæ*) from New Zealand, presented by Mr. Alfred M. Simon; two Razorbills (*Alca torda*), two Guillemots (*Lomvia troile*), British, presented by Mr. W. B. Roberts; a White-throated Monitor (*Varanus albogularis*) from South Africa, presented by Mr. H. L. Jones; a Macaque Monkey (*Macacus cynomolgus*) from India, two Argus Pheasants (*Argus giganteus* ♂ ♀) from Malacca, a Military Macaw (*Ara militaris*) from South America, deposited; an Indian Coucal (*Centropus rufipennis*) from India, two Diamond Snakes (*Morelia spilotes*) from New South Wales, received in exchange.

OUR ASTRONOMICAL COLUMN.

COMET 1889 *d* (BROOKS, JULY 6).—The comet reported in NATURE of July 11 (p. 255) as having been discovered by Swift on July 5 appears to have been an observation of Barnard's comet of 1888 September 2, there having been an error in the transmitted position. The position should have been:—

R.A. 21h. 24m. 20s. N.P.D. 89° 11′.

A faint comet was discovered by Brooks on July 6.

July 6·790 G.M.T.; R.A. 23h. 44m. 8s.; N.P.D. 99° 9′. A rough approximation by Brooks.

July 8·9561 G.M.T.; R.A. 23° 46′ 26″; N.P.D. 98° 55′ 57″. Observation by Barnard. Comet, slightly elongated, 1′ in diameter, 11 mag. or fainter.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JULY* 21–27.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on July 21

Sun rises, 4h. 10m.; souths, 12h. 6m. 8·4s.; daily increase of southing, 2·8s.; sets, 20h. 1m.: right asc. on meridian, 8h. 3·9m.; decl. 20° 24′ N. Sidereal Time at Sunset, 16h. 0m.

Moon (two days after Last Quarter) rises, 23h. 54m.*; souths, 7h. 0m.; sets, 14h. 19m.: right asc. on meridian, 2h. 56·6m.; decl. 12° 12′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	2 42	10 51	19 0	6 49·0	22 23 N.
Venus.....	1 4	8 53	16 42	4 49·9	19 22 N.
Mars......	3 13	11 25	19 39	7 23·5	23 0 N.
Jupiter....	18 7	22 1	1 55*	18 0·9	23 21 S.
Saturn....	6 9	13 35	21 1	9 33·3	15 43 N.
Uranus...	11 39	17 9	22 39	13 8·0	6 34 S.
Neptune..	0 23	8 12	16 1	4 9·1	19 22 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
δ Libræ	14 55·1	8 5 S.	July 25,	2 57	*m*
U Coronæ	15 13·7	32 3 N.	,, 27,	2 38	*m*
U Herculis	16 20·9	19 9 N.	,, 22,		*m*
U Ophiuchi	17 10·9	1 20 N.	,, 23,	22 31	*m*
X Sagittarii	17 40·6	27 47 S.	,, 21,	23 0	*M*
W Sagittarii	17 57·9	29 35 S.	,, 23,	23 0	*M*
U Sagittarii	18 25·6	19 12 S.	,, 26,	1 0	*m*
R Scuti	18 41·6	5 50 S.	,, 23,		*M*
β Lyræ	18 46·0	33 14 N.	,, 24,	23 30	*M*
R Lyræ	18 52·0	43 48 N.	,, 21,		*M*
U Aquilæ	19 23·4	7 16 S.	,, 24,	21 0	*m*
η Aquilæ	19 46·8	0 43 N.	,, 26,	23 0	*M*
S Delphini	20 38·0	16 41 N.	,, 26,		*M*
X Cygni	20 39·1	35 11 N.	,, 24,	2 0	*M*
T Vulpeculæ	20 46·8	27 50 N.	,, 21,	23 0	*m*
δ Cephei	22 25·1	57 51 N.	,, 23,	0 0	*m*

M signifies maximum; *m* minimum.

July.	h.	
23 ...	21 ...	Venus in conjunction with and 0° 41′ south of the Moon.
26 ...	20 ...	Mercury in conjunction with and 0° 19′ south of the Moon.
26 ...	23 ...	Mars in conjunction with and 0° 1′ south of the Moon.

Meteor-Showers.

	R.A.	Decl.	
Near γ Draconis	270 ...	50 N. ...	Swift.
From Lacerta	335 ...	50 N. ...	Swift.
	350 ...	52 N. ...	Very swift.

BABYLONIAN ASTRONOMY.[1]

III.

WHEN names had to be given to stars, the Babylonians naturally took them from the objects around themselves. The heavenly host was compared to an immense flock, and several stars were grouped together to form the imaginary figure of either a bull, or a ram, or a goat, &c. It is too often taken for granted that the constellations have received certain names, and that the march of the sun through these signs has given birth to various legends, but those who see everywhere solar myths do not say why the constellations were so named. The names given to them must have some connection with what took place at their appearance, mark the seasons, or indicate the work, agricultural or other, of the seasons. The stars of the ecliptic, placed on the path of the planets, were associated with the monthly motion of the moon, and divided accordingly into thirty groups. Each of these constellations was one of the houses of the moon, and marked in the sky the course followed by it in one day.

The constellations were but indirectly connected with the sun's journey through the ecliptic. The acronic, not the heliac, rising of the stars and signs was especially observed, for those which were shining all through the nights of a certain period were considered as the protecting gods of that period.

Many of the allegorical figures representing the constellations were engraved on the boundary stones as images of protecting divinities, and they show the process by which the Babylonian artists arrived at the creation of the composite animals that still adorn our celestial globes. For instance, the Goat coming after Aquarius was represented as coming out of the water, and the hind part of its body changed into that of a fish. Sometimes three or more constellations were combined to form one figure: the horse, the scorpion, and the bow gave birth to a Centaur, holding a bow, and having a scorpion's tail—our Sagittarius.

When the zodiac was borrowed from Babylonia by the Egyptians, they adopted these very un-Egyptian images. There is still some uncertainty as to the date at which the borrowing took place, for all the Egyptian zodiacal representations are posterior to Alexander, but the idea may have been imported about 1600 or 1500 B.C. The Egyptians did not borrow bodily, however, the Babylonian zodiac of thirty signs, but adapted it to their solar year, and according to their sun-worship ideas, so the thirty signs were reduced to twelve, and were connected with the sun's march through the ecliptic. The thirty-six decans were in the same way connected with the sun's march, and three given to every month or ecliptic constellation, one therefore marking the space covered by the sun in ten days.

All attempts made as yet to identify the Babylonian names of stars have failed, because there was no base or starting-point. But now, with the list of the thirty constellations answering to the thirty divisions of the sky, identification is practically easy. In this work we are also helped by the classifications made by the augurs of Babylon for omen-taking; for instance, the twelve stars of the south must be stars of the austral hemisphere. We must at the same time take into account any mention made of stars in the inscriptions, and not forget that the acronic rising was the one observed and noticed by the Babylonians. By this comparative method it can be determined, for instance, that the star *Sukudu* or *Kak-si-di* was Sirius, for we are told that it was one of the seven most brilliant stars, and a star of the south; as it does not appear in the list of the thirty groups of stars, marking the path of the moon, it must be at a certain distance from the ecliptic. In several inscriptions the appearance of this star is used to determine a date; it must therefore appear only for a very short period. This same star is also called "directing star," because connected with the beginning of the year.

By a similar process we can determine that the star *Su-gi* was Canopus; the star *Iku* (or *Dil-gan*), Fomalhaut; the star *Sib-zi-an-na*, α Centauri; the star *Id-khu*, Altair; &c.

The thirty constellations dividing the ecliptic are not, however, all exactly on this line; for instance, one of them is *Sar* or *Merodach* (Orion), another is "the Sceptre of Bel" (Procyon). Having once identified several of these thirty constellations or stars, it is easy to identify the others, as the list is given in the tablet according to their order. We are also helped in our work of identification by the Egyptian zodiac, and the names preserved by Ptolemy. In Egypt, Merodach has become Horus, and the "Sceptre of Bel" that of Osiris. In some cases we can even identify the name of a constellation, though we are not able to pronounce it on account of its being written with a group of ideograms.

The Babylonians often, in star nomenclature, confounded a star with the constellation it belonged to, and substituted for the name of a star that of the god associated with it. We must also take into account the two different points of view adopted by the Babylonian astronomers and their Egyptian imitators.

[1] Abstract of the third lecture delivered by Mr. G. Bertin, at the British Museum. Continued from p. 261.

SCIENTIFIC SERIALS.

Revue d'Anthropologie, troisième série, tome iv., troisième fasc. (Paris, 1889).—Examination of human bones found by M. Piette in the walled-in cave at Gourdon, by Dr. Hamy. The results of M. Piette's explorations, although of some interest, have not contributed very largely to our acquaintance with human fossil bones, owing to the fractured and mutilated condition of these finds, which, as is often the case in cave-deposits, were limited to cranial bones, the maxillaries, and one or two of the upper cervical vertebræ. The most perfect of these were found in the middle of the walled cave in *débris* of reindeer and other animal bones, together with carved reindeer horns, cut flints and stones, and numerous stone hatchets, chisels, scrapers, &c., these remains being similar to objects found in other prehistoric stations in the south of France belonging to the reindeer period in Central Europe. At a more remote part of the cave M. Piette discovered a deposit, containing implements of a more ancient type, intermingled with the bones of the mammoth and bear, as well as of the reindeer. The human lower-jaw, found here at a depth of 15 feet, has the special character of analogous cranial remains derived from the Naulette and Spy caves, and belonging to the most ancient type of primæval man, whom MM. De Quatrefages and Hamy include under the name of the Canstadt race.—On the gold of ancient Gaul, by M. Cartailhac. The writer gives a detailed account, with numerous illustrations, of the various gold ornaments found in France, and shows how numerous are the instances in which large and splendid treasures of older art have been irreparably lost in consequence of the finders having consigned them to the melting-pot of the local goldsmith, a practice which can only be stopped by an alteration in the state of the law regarding treasure-trove. The extreme beauty of some of the bracelets, necklets, &c., and the unique character of their ornamentation, are unsurpassed by other objects of the same kind found in different parts of Europe.—Notes on the colour of the eyes and hair in Norway, by Drs. Abbo and Faye, with tables and annotations, by M. Topinard. From these reports it appears that the population of Norway exhibits a higher percentage (97·25) of light eyes than any other country in Europe. Flaxen hair occurs in 57·5 per cent. of the people of the northern provinces, and while absolutely black hair is found only in the ratio of 2 per cent., red hair does not rise higher than 1·5 per cent. in the scale of hair-coloration.—Kashgaria, by Dr. Seeland. In this notice the writer records the incidents of his journey from Kashgar to Ak-Sou, over a distance of more than 350 miles along the sandy ill-kept track that constitutes the principal military Chinese post road. The narrative lacks the interest of the previous numbers already referred to in this journal.—On the cephalic index of the Provençal population, by M. Fallot, with tables referring to the several departments, which give the varying maxima and minima in accordance with special cranial types.—Hallstatt in Austria, its places of burial, and its civilization, by Dr. Hörnes. This is an extremely interesting summary of the important discoveries made within the last few years in the Hallstattian burying-grounds of Slavonian Austria, more especially at Watsch in Carniola, where the beauty and finish of the carved baldrics and belts have led contemporary palæontologists to regard them as an evidence of the existence in Central Europe of an early civilization which had already attained to considerable artistic culture before its extinction under the weight of advancing hordes of barbarian invaders. The necropolis of Hallstatt, for our acquaintance with which we are indebted to Baron Sacken, still remains unrivalled for the splendour and variety of its antiquities, notwithstanding the marvellous results of the recent Carniolian and Croatian finds. Between 1846 and 1863, Sacken and Ramsäuer published reports of their explorations of nearly 1000 tombs; while since that period the number of graves explored has risen to nearly 1900. Both at Hallstatt and Watsch the rites of interment and incineration had been followed with nearly equal frequency, but although in the case of the latter the graves appear to have been most richly supplied with gold ornaments and carved bronze arms, the abundance of yellow amber, and of decorative objects of the toilet which are found buried with the unburnt skeletons render it difficult to decide which of the two methods of disposing of the dead was regarded as the more distinguished. The cranial type is generally dolichocephalous, with a retreating forehead and long slightly prognathic face, resembling what is known in Germany as the "Reihengräbertypus." According to Sacken, the necropolis of Hallstatt dates from the third or fourth century B.C., revealing the presence in those regions of the Eastern Alps of the so-called Galli Faurisci, who prior to the Roman domination must have been familiar with an advanced stage of civilization and decorative art, in which the influence of Greek art is undeniable. This is indeed strongly manifested both in the workmanship and the forms of multitudinous objects revealed by the exploration not merely of the Hallstattian tombs, but of the prehistoric station of Salzberg, whose discovery last year has added new interest to the still contested problem of the origin of the early culture of the Alpine races of Central Europe.

Rivista Scientifico-Industriale, May 15.—On sand showers, by Prof. P. Francesco Denza. His protracted observation of this meteoric phenomenon leads the author to infer that it is not sporadic, as is commonly supposed, but periodical, though subject to occasional disturbances. Its recent reappearance in several parts of Italy, after a considerable interruption, confirms the opinion already advanced by him, that the sands have their origin in the North African deserts, whence they are borne by the high southern gales as far as, and occasionally even beyond, the Alps. About the beginning of May atmospheric waves of low pressure advanced from West Africa across the Mediterranean to South-West Europe, causing a heavy rainfall as far north as the British Isles. In Sicily and Piedmont the showers were mixed with sands, while elsewhere the foliage was covered with a perceptible layer of dust. On May 12 a violent sandstorm raged in the North Sahara, as announced by telegrams from Biskra (Algeria), and this was soon followed by fresh downpours and by another shower of sand in North Italy far more intense than the first. In many parts of the Ligurian Alps and of Lombardy not only the vegetation, but the roofs of houses, terraces, marble monuments (in Turin and Milan), were strewn with fine particles, specimens of which were collected in various districts. The coincidence of the African simoom and the Mediterranean scirocco charged with sand leaves no doubt as to the real origin of the phenomenon popularly attributed to the effects of the April *luna rossa* ("red moon"). Prof. Denza's interesting communication is dated from the Observatory of Moncalieri (Piedmont), May 18, 1889.

Bulletin de l'Académie Royale de Belgique, May.—On a new method of testing for bromine, by Fréderic Swarts. This method, which yields excellent results, is based on the well-known fact that resorcinic phtalin (fluorescin) is transformed to its tetra-bromuretted derivative (eosine) characterized by a beautiful pink colour. The reaction consists in liberating hydrobromic acid, which is immediately oxidized by the hypochlorous acid. The bromine thus obtained then acts on the fluorescin, converting it into eosine, which is transformed to a pink salt under the influence of a slight excess of alkali. This reaction is so sensitive that it succeeds with a tenth of a cubic centimetre of water containing a hundred-thousandth of potassium bromide, a quantity corresponding to a thousandth of a milligramme of this salt. In the case of iodine, it detects the presence of bromine in sea-water without submitting it to any preliminary treatment.—G. Van der Mensbrugghe describes a curious experiment in capillary attraction, the explanation of which is reserved for a future communication. The subject has engaged this physicist's attention since the year 1883, when he announced a simple method of demonstrating the contractile force of fluids which cannot easily be reduced to thin seams (*lames*).

Das Wetter (Brunswick) for June contains an article, by Dr. B. Andries, on the cold period of May, which generally obtains about the 10th of that month; the 11th to 13th being known as the three "ice-saints." There is no doubt that each year frosts occur in May, after several days of warm weather have led us to hope for continued increase of temperature. But the author shows, from long series of observations at Bremen and Paris, that the same thing occurs in April and June, and that the weather of May is more uniform than all the other months, except October, which exhibits the same regularity in decrease of temperature that May does in the increase of the same. The variability arises from the influence of cyclones advancing from the Atlantic. In the interior of the Continent, the temperature becomes more constant, as the influence of the ocean becomes less. Dr. R. Assmann (the editor of the journal) contributes an article on the microscopic observations on the structure of hoar-frost, &c., made on the Brocken and elsewhere. His observations seem to show that hoar-frost is not always crystalline, but that, if the temperature is only slightly below the freezing-point, the hoar-frost, or rime, is often composed of amorphous particles of ice. A third article, by an anonymous writer, deals with the winters of the south coast of the Crimea. The climate is far from unpleasant; in a normal year, a brilliant autumn follows a dry summer, and a soft air continues far into November. December is generally cold and wet, and January fine; hard frosts do not occur till February, and then the struggle between winter and spring lasts until April. An interesting phenological table is added, showing the different effects upon vegetation between a wet or dry November and December.

Bulletin de l'Académie des Sciences de St. Pétersbourg, nouvelle série, i. (xxxiii.), No. 1.—With this number the *Bulletin* begins a new series, printed in a handy octavo shape.—On the rattle-apparatus of *Crotalus durissus*, by A. Feoktistoff.—On a simplification of Wild's photometer, by H. Wild.—On the solution of mechanical problems resulting in hyperelliptic differential equations, by C. Charlier.—Entomological contributions, by A. Morawitz, being a description of two new Central Asian species of *Carabus* (*C. pupulus* and *C. eous*), and a detailed monograph of many species of the same genus.—On the embryology of *Pteromyzon fluviatilis*, by Ph. Owsjannikoff.—Researches relating to the basicity of antimonic acid, by F. Beilstein and O. Blaese.—On the preparation of rubidium, note by N. Beketoff.—On a new Central Asian Siluroid (*Exostoma oschanini*), by S. Herzenstein.—On the absence of the common squirrel in Caucasia, by E. Büchner. Although Pallas, Nordmann, and Ménétries mentioned the *Sciurus vulgaris* as occurring in the Caucasus, there is not the slightest mention of it in the descriptive parts of their works, nor any representative of it in Ménétries's otherwise remarkable collection, kept in full at the Academy. The common squirrel could not be discovered in the Caucasus by the late M. Bogdanoff, nor by MM. Rossikoff, Mlokossewicz and Ananoff, who searched for it for years. It may have been that Pallas, Nordmann, and Ménétries simply reported the words of the Caucasus Cossacks, who give the Russian name of *byelka*—usually applied to the squirrel—to *Myoxus glis*, which really appears in the Northern Caucasus. It is also worthy of note that the common squirrel does not appear in the Crimea.—Hydrological researches, by Carl Schmidt. Analyses of the thermal springs at Saniba, in the north of Mount Kazbek.—Analyses of the sulphate of aluminium, by Beilstein and Grosset.

SOCIETIES AND ACADEMIES.

London.

Entomological Society, July 3.—Lord Walsingham, F.R.S., President, in the chair.—A letter was read from Mr. E. J. Atkinson, Chairman of the Trustees of the Indian Museum, Calcutta, in which assistance was asked from British entomologists in working out various orders of Indian insects.—The following motion, which had previously been unanimously passed at the meeting of the Council, was read to the Society:—"That papers containing descriptions of isolated species widely remote in classification or distribution are, as a rule, undesirable for publication, as tending to create unnecessary difficulties for faunistic or monographic workers." Mr. McLachlan, Mr. Jacoby, Mr. Elwes, Dr. Sharp, and others took part in the discussion that followed.—Mr. McLachlan, on behalf of Prof. Klapálek, of Prague, who was present as a visitor, exhibited preparations representing the life-history of *Agriotypus armatus*, Walk., showing the curious appendages of the case. Prof. Klapálek, in answer to questions, described the transformations in detail. A discussion followed, in which Mr. McLachlan and Lord Walsingham took part.—Mr. H. J. Elwes exhibited a specimen of an undescribed *Chrysophanus*, taken in the Shan States, Upper Burmah, by Dr. Manders, which was very remarkable on account of the low elevation and latitude at which it was found; its only very near ally appeared to be *Polyommatus Li*, Oberthur, from Western Szechuen, but there was no species of the genus known in the Eastern Himalayas or anywhere in the Eastern tropics.—Mr. G. T. Porritt exhibited a remarkable series of *Arctia mendica*, L., bred from a small batch of eggs found on the same ground at Grimescar, Huddersfield, as the batch from which the series he had previously exhibited before the Society was bred. This year he had bred forty-five specimens, none of which were of the ordinary form of the species: as in the former case, the eggs were found perfectly wild, and the result this year was even more surprising than before.—Mr. R. W. Lloyd exhibited specimens of *Harpalus cupreus*, Steph., and *Cathormiocerus socius*, Boh., recently taken at Sandown, Isle of Wight.—Mr. O. E. Janson exhibited a fine male example of *Theodosia howitti*, Castelnau, a genus of *Cetoniidæ* resembling some of the *Dynastidæ* in the remarkable armature of the head and thorax. The specimen had recently been received from North-West Borneo.—Mr. W. White exhibited specimens of *Heterogynis paradoxa*, Ramb., and stated that this insect represented an extreme case of degeneration, the mature female being only slightly more developed than the larva, the prolegs being quite atrophied. Lord Walsingham made some remarks on the subject.—Mr. T. R. Billups exhibited a fine series of the very rare British beetle, *Medon (Lithocharis) piceus*, Kr., taken from a heap of weeds and vegetable refuse in the neighbourhood of Lewisham on May 19.—Mr. W. F. Kirby read a paper entitled "Descriptions of new species of Scoliides in the collection of the British Museum, with occasional reference to species already known."—Mr. J. B. Bridgman communicated a paper entitled "Further additions to the Rev. T. A. Marshall's Catalogue of British Ichneumonidæ."—Mr. J. S. Baly communicated a paper entitled "On new species of *Diabrotica* from South America."

Anthropological Institute, June 25.—Dr. John Beddoe, F.R.S., President, in the chair.—Prof. Victor Horsley exhibited some examples of pre-historic trephining and skull-boring from America.—His Excellency Governor Moloney, C.M.G., exhibited some cross-bows, long-bows, quivers, and other weapons of the Yorubas.—The Rev. Dr. Codrington read a paper on poisoned arrows, in which he stated that the natives relied upon the words of incantation used during the manufacture of the arrows much more than the toxical effect of any substance into which they might be dipped or which might be smeared upon them; indeed, that in many cases the so-called "poisoned arrows" were not poisoned at all.—A paper by Mr. Henry Balfour, on the structure and affinities of the composite bow, was read.

PARIS.

Academy of Sciences, July 8.—M. Des Cloizeaux, President, in the chair.—On two new mechanical appliances, by MM. G. Darboux and G. Kœnigs. The first of these apparatus has been devised for the purpose of describing a plane in space by means of jointed rods; the second supplies a representation of the movement of a solid body revolving freely round its centre of gravity. The principles are described on which both have been constructed.—On the relations between the fractures in the terrestrial crust of a given region, and the seismic movements of the same, by M. A. F. Noguès. The author's comparative study of earthquakes in various parts of the world has led him to detect certain relations between these disturbances and the breaks of continuity in the surface of the earth. In the present paper he shows that, in a given seismic region offering a complicated system of fractures and faults varying in direction, size, and depth, the underground convulsions are correlated with some one of these systems, and entirely independent of the others. His illustrations are drawn mainly from the seismic zone of Andalusia, extending from Séville to the frontier of Murcia.—Influence of temperature on the mechanical properties of iron and steel, by M. André Le Chatelier. In continuation of his previous paper on this subject, the author here gives the results in detail for iron and steel, which are shown to behave quite differently from other metals under like variations of temperature. Three chief phases are distinguished, ranging respectively from 15° to 80° C.; from 100° to about 240°; and from 240° upwards.—On the solubility of carbonic acid gas in chloroform, by M. Woukoloff. Continuing his researches on the law of solubility of the gases, the author here studies the conditions of the solution of carbonic acid in chloroform. With the data obtained he finds that at a temperature of 13° C. his solution does not conform strictly to Dalton's law, although the deviations are very slight, as was also shown to be the case for the bisulphide of carbon.—On the solidification of nitrous acid, by M. Fl. Birhans. In his attempts to solidify anhydrous nitric acid still containing small quantities of hyponitrous acid, the author found that it was necessary to operate at a temperature of from $-52°$ to $-54°$, obtained by the evaporation of the methyl chloride by means of a current of dry air.—On the cobaltites of baryta, and on the existence of a dioxide of cobalt with acid properties, by M. G. Rousseau. The experiments here described demonstrate the existence of a cobaltous acid analogous to manganous acid, but weaker. The maximum of stability of the manganite of baryta appears to be situated in the neighbourhood of 1100° C. At lower or higher temperatures this compound becomes dissociated like the hydrocarburets heated to the point of decomposition.—On an oxybromide of copper analogous to atacamite, by M. Et. Brun. M. Berthelot has noticed that when a clear solution of cuprous chloride in cupric chloride is exposed to the air, a greenish precipitate of oxychloride is formed, which is "probably identical with atacamite." The same reaction is produced by substituting for the cuprous chloride as a solvent the ammonium, sodium, and potassium chlorides. From the last two is obtained a crystalline powder, yielding on analysis the numbers corresponding to the formula of atacamite: $CuCl, 3CuO, 4HO$. M. Brun's present researches aim at the production of an oxybromide of copper from the corresponding bromides. The substance thus obtained possesses a constitution analogous to atacamite, which it closely resembles in its properties and mode of formation.—On the disturbances of the vision consequent on microscopic observation, by M. J. J. Landerer.—The large bones of the anthropoid apes, by M. Etienne Rollet. Since his communication of December 10, 1888, the author has made fresh measurements on the complete skeletons of forty-two adult apes, the results of which are here given in detail. From a comparative study of these figures it appears that the gorilla and chimpanzee approach nearest to man, but in different degrees, the orang holding the third place. But great differences exist between the proportions of the human frame and those of all the bimanous apes.

BERLIN.

Physical Society, June 21.—Prof. Kundt, President, in the chair.—Dr. Fröhlich demonstrated experimentally his new method of recording vibrations in the form of curves; the method has been recently described verbally to the Society. Light from an electric arc-lamp was made to fall upon a small mirror, attached either to the vibrating plate of a telephone, or to a piece of card covered with a thin film of iron, or to a thin india-rubber membrane. From this mirror it was reflected on to a polygonal rotating mirror, and by this on to a transparent screen, being thus made visible to the whole audience either as a spot of light when the rotating mirror was at rest, or as a line of light when it was set in motion. On sounding various organ-pipes in front of the receiver of the telephone, many very pretty curves were seen; on singing the vowels into the telephone, very characteristic curves were seen crossing the screen; so also with the consonant *r*, whereas on the other hand *s* produced no effect. The next experiment consisted in connecting the rotation of the mirror with the interrupted electric current, whose action was under investigation, in such a way that the vibrations of the membrane produced by the current gave rise to persistent curves upon the screen. The current from a battery produced an interrupted sinuous line of light, in which each rise of the curve was somewhat slower than the steeper fall of the same. On introducing a coil into the circuit the curve showed no change as long as the telephone was in front of the coil; when it came behind the coil, the curve described was almost a sine-curve. On putting an electro-magnet into the circuit the amplitude of the curves was less; so also when self-induction existed in the circuit, while at the same time the rise and fall of each part of the curve was less steep. A condenser gave rise to a curve with very sharp-pointed sinuosities. An apparatus for producing alternating currents gave rise to a regular sine-curve, which was affected by a co.l electro-magnet and condenser in the same way as was the curve due to a battery current. Lastly, experiments were made with an induction-coil. On placing the telephone in the primary circuit, the vibrations of its plate gave rise to uniform sine-waves, whose height was less when the telephone was introduced into the secondary circuit, while at the same time they showed a phasic difference of $\frac{1}{4}$ wave-length. This change of phase due to induction, as exhibited in most striking manner to the large assembled audience, can be recorded by photography of the curves and thus submitted to exact measurement.—Prof. Gad gave a short account of researches made, in conjunction with Dr. Heymans, on the effect of temperature upon muscular contraction. These are to be the subject of a more extended communication to the Physiological Society.

Physiological Society, June 28.—Prof. du Bois-Reymond, President, in the chair.—Prof. Gad gave an account of experiments which he had made, in conjunction with Dr. Heymans, on the influence of temperature upon the working-power of muscles. In accordance with Fick's procedure, the muscles were experimented upon not only in an isotonic condition, where there is no change of initial tension, and stimulation leads merely to a shortening of the muscle, but also in an isometric condition, where there can be no change of length in the muscle, and stimulation produces only a change of its tension. Various muscles from frogs were examined at temperatures of 36°, 30°, 13°, 5°, 0°, and − 5° C., being freely suspended in a metallic cylinder immersed in a water-bath. The muscles were stimulated electrically by maximal and super-maximal induction-shocks due to breaking the primary circuit, these being single or repeated or tetanizing. The curve of the isotonic muscle was symmetrical at 19° C.; at 5° C. it rose much more slowly, and was both higher and longer than at 19° C. At temperatures down to and below 0° C. the rise of the curve was still slower and its height less than at 5° C., but on the other hand its length was greater. At higher temperatures the height of contraction was greater than at 5° C., the duration less than at 19° C., and the curve of contraction was symmetrical. At still higher temperatures there was a very considerable fall in the height of contraction, and its duration was still shorter than before. Irritability disappears immediately before the occurrence of heat-rigor. The curves of a muscle in the isometric condition were an exact reversal of those for the isotonic: low and short at 40° C. to 36° C., they were longer and very high at 30° C. At 19° C. there was a very marked diminution in height, while the length was slightly greater; at 5° C. the curve was again higher than at 19° C. and much longer, and below 0° C. lower and longer. When stimulated by a tetanizing current the curve of the isotonic muscle was highest at 30° C., but fell very rapidly from this height, a sign of rapid exhaustion. At 19° C. the curve rose to a less height, and less precipitately, and fell quite suddenly on the cessation of the stimulus. At 5° C. the curve rose more gradually to a less height, and was prolonged considerably after the stimulus was removed, and this was also the case at temperatures below 5° C. The curve of tetanus for an isometric muscle was again, as in the case of single contractions, an exact reversal of that obtained from an isotonic muscle. When discussing the results of the above experiments, the author gave special prominence to the facts that the height of the curve of contraction is least at 19° C. (the temperature of the room) and is increased by either warming or cooling the muscle; further that the duration of the contraction, which is about 0·1–0·2 second at 19° C., increases rapidly as the temperature falls, and is as much as 2·6 seconds at − 5° C. In explanation of the first fact the author assumed that, in accordance with Fick's hypothesis, during the conbustion of carbohydrates and fats to carbon-dioxide and water some intermediate product (? lactic acid) is formed, and acts as a stimulus: the various temperatures under which the muscle works must then be supposed to have varying influences upon the formation and subsequent final oxidation of this intermediate product.—Dr. Obermüller described a new reaction for cholesterin which he had discovered. It consists in treating cholesterin with propionic-anhydride; this leads to the formation of a compound of propionic acid and cholesterin, which on being fused and allowed to cool shows, even in minute traces of the substance, a fine play of colours from violet through blue and green to red. In the green stage the compound consists of minute spheroidal crystals, which are larger in the red stage, and show a black cross when examined between crossed Nicols.

Vienna.

Imperial Academy of Sciences, April 11.—The following papers were read:—On the constitution of the quinine-alkaloids, by H. Skraup.—On some aldehyde-like products of the condensation of urea and their tests, by E. Luedy.—Remarks on the comet discovered by Barnard on March 31, by E. Weiss.—On the diffusion of bases and acids, by E. Stefan.—On desiccative oleic acids, by K. Hazura.—On oxidation of non-saturated fatty acids by potassium permanganate, by A. Gruessner and K. Hazura.—Contribution to the flora of the East (on the plants collected in 1885 in Pamphylia by Dr. Heider), by R. von Wettstein.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Matriculation Directory, No. 6, June 1889 (Clive).—A Text-book of General Therapeutics: W. Hale White (Macmillan).—Lord Howe Island, its Zoology, Geology, and Physical Characters (Sydney, Potter).—Fallow and Fodder Crops: J. Wrightson (Chapman and Hall).—The Fauna of British India, including Ceylon and Burma; Fishes, vol. i.: F. Day (Taylor and Francis).—Veröffentlichungen der Grossherzoglichen Sternwarte zu Karlsruhe, Drittes Heft: Dr. W. Valentiner (Karlsruhe).—Annalen der k. k. Universitäts-Sternwarte in Wien (Währing), v. and vi. Band (Williams and Norgate).—Ancient Art of the Province of Chiriqui, U.S. of Columbia; W. H Holmes (Washington).—A Study of the Textile Art: W. H. Holmes (Washington).—The Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the Blind Species (National Academy of Sciences, vol. iv., First Memoir).—Who are the American Indians: H. W. Henshaw (Washington).—Journal of Anatomy and Physiology, July (Williams and Norgate).

CONTENTS.

THURSDAY, JULY 25, 1889.

COMMERCIAL ORGANIC ANALYSIS.

Commercial Organic Analysis. A Treatise on the Properties, Proximate Analytical Examination, and Modes of Assaying, the Various Organic Chemicals and Products employed in the Arts, Manufactures, Medicine, &c.; with Concise Methods for the Detection and Determination of their Impurities, Adulterations, and Products of Decomposition. By Alfred H. Allen, F.I.C., F.C.S. Second Edition, revised and enlarged. Volume III., Part I. (London: J. and A. Churchill, 1889.)

IN this instalment of the amplified edition of Mr. Allen's well-known and valuable work of reference, the substances dealt with are the acid derivatives of phenols, also including aromatic acids and tannins, dyes, and colouring matters; the large additions made to the first edition necessitating the division of the concluding volume into two parts, of which this is the first, the discussion of organic bases, cyanogen compounds, and albuminoids, &c., is reserved for the second part. In consequence, the large majority of the present portion is entirely new, only comparatively short sections on picric acid and basic aniline derivatives having appeared in the first edition, in place of some 270 pages relating to dye-stuffs. Where references to English translations or abstracts of foreign papers are obtainable, the author has deliberately given them in preference to references to the original memoirs appearing in German and other foreign periodicals, on the ground that these publications "are practically, if not absolutely, inaccessible to the great majority of English readers." No doubt so doing saves a considerable amount of trouble to the reader in the first instance; but, on the other hand, concise abstracts such as are to be found in the Journals of the Chemical Society and the Society of Chemical Industry, NATURE, the *Chemical News*, the *Pharmaceutical Journal*, &c., are frequently of necessity shorn of many details of especial importance to the commercial analyst; whilst most chemists concerned in the analysis of dye-stuffs and analogous organic products probably possess in their own libraries the leading German and other periodicals, or at least have access to them in the various public libraries in the manufacturing towns and cities.

Amongst the phenol and aromatic derivatives Fahlberg's *saccharine* (benzoyl sulphonic imide) finds a place; this is stated by the author to be "quite uninjurious, even when taken in considerable quantities," passing unchanged through the system, so that it can be detected in the urine. It would seem, however, that the alleged freedom from noxious effect is a matter still somewhat in dispute, at any rate as regards habitual use; the difference of opinion on the subject being one reason why the Commissioners under the Customs and Inland Revenue Act of 1888 exercised their discretion in prohibiting the use of saccharine in beer (May 1888) until further notice. For similar reasons, the addition of salicylic acid to wine is forbidden in France and other countries, although only one part in 10,000 is essential even as a maximum for the preservation of the liquid; magenta being also prohibited as a tinting material for sweetmeats, wines, &c., on account of the frequent presence of arsenic therein. The use of picric acid as a bitter for beers or "hop substitute" is rightly condemned by the author, on account of the distinct poisonous properties of the substance, rabbits and dogs being killed by doses of from 0·06 to 0·60 gramme (nearly one to ten grains); similarly the employment of dinitro-cresol and naphthalene yellow as "saffron surrogates" for tinting butter, cheese, maccaroni, &c., is strongly objected to on the same ground. In all these and many other instances the various methods of detection of the objectionable substances are carefully detailed, the book being largely intended for the use of the public analyst in connection with articles of food and drugs, as well as for chemists and specialists working in other directions. One of the tests for salicylic acid in beer, recommended on the authority of Blas, is of a somewhat heroic character, and is hardly likely to be adopted by toxicologists as a process of general application: the analyst is required to *drink the beer*, and, after three hours, to examine his urine, the colour-reaction with ferric chloride being stated to be then seven times as delicate as with the original beer. Probably it is the adoption of analytical methods of this description that has led to the popular belief that an analytical certificate of having examined edibles "chemically, physiologically, and dietetically, without finding anything injurious to health in them," simply implies that the operator has lunched on the materials, and has not noticed any particular inconvenience resulting therefrom. In cases where injurious substances are believed to be present, it might be preferable to make the vendor of the suspected goods the medium for the application of the test, thus to some extent returning to the mediæval practice of punishing sellers of adulterated wine by compelling them to swallow a gallon or two of the liquor, and pouring the remainder of their stock over them as an external application of a sobering nature.

In the same section, the general chemistry of the tannins is discussed, so far as it is at present understood, and the various processes described for the valuation of the numerous tannin-yielding materials occurring in commerce. From the tanner's point of view, these are divisible into two great classes, viz. those which produce a "bloom," or fawn-coloured deposit on leather (such as gall-nuts, divi-divi, sumach, valonia, and oak-bark), and those which do not (such as catechu, hemlock, larch, and mimosa); broadly speaking, these two classes yield, with ferric acetate, somewhat different colorations, the first set producing a blue-black, and the second a green, the difference being mainly due to the presence of gallic acid and protocatechuic acid, or derivatives thereof, in the two classes respectively. Curiously, the author has omitted to give, in this connection, any directions for the testing of manufactured *leather*, the adulteration of which with sulphate of barium (mechanically forced in whilst moist and soft), glucose, and analogous weighting substances, has of late years come somewhat prominently into notice, and indeed occasioned special Government inquiry. In connection with tannin, some interesting facts are recorded concerning the examination of documents in cases of suspected forgery or alteration where ordinary ink has been used, more recent writing being frequently capable of detection by the use of chemicals carefully painted on (such as dilute hydrochloric or oxalic acid solution), on account of its fading out sooner under the treatment. Stephen's blue-black ink is described as composed of 15 parts galls, 5 ferrous sulphate, 4 iron filings, 200 water, and ½ indigo, in 3 of sulphuric acid, no gum, or other thickening being mentioned, whilst other inks usually contain a few per cents. of such substances, copying-inks chiefly differing in containing sugar or glycerine in addition. Sulphate of copper is stated to be added occasionally to inks "with questionable advantage"; the opinions of the vendors and users of steel pens on this point being doubtless dissimilar.

The major half of the book consists of a terse description of the general processes of manufacture, characteristics, and modes of examination of dye-stuffs, classified under the headings of nitro colouring matters, nitroso colouring matters, aurin and its allies, phthaleïns, azo colouring matters, rosaniline and its allies, safranines and indophenols, colouring matters from anthracene, sulphuretted and unclassified coal-tar dyes, and colouring matters of natural origin. On reading the systematic names of many of the artificial dye-stuffs, one can hardly wonder that practical dyers prefer to employ shorter and more colloquial terms, even though these lack somewhat in scientific precision: "xylidene-scarlet," for example, although not absolutely euphonious, is still a much more pronounceable word than sodium xylene-azo-beta-naphthol-alpha-disulphonate; whilst "night blue" is far less mouth-filling than hydrochloride of tetra-methyl-tolyl-tri-amido-alpha-naphthyl-diphenyl carbinol! It is, however, to be regretted when new dye-stuffs are designated by names already well known in connection with substances of wholly different chemical character: thus *narceine* is ordinarily understood to refer to one of the alkaloids of the opium family; but the term has also been applied to one of the modern hydroxy-azo-naphthol dye-stuffs. In describing the matter treated of in this section, the author is well up to date, such recent introductions to commerce as Green's "primuline," and the various derivatives thereof obtainable *in situ* on cotton goods by the "in-grain" process, being included. Suggestions also as to the direction which scientific investigation might take in improving certain technical processes are not wanting: for example, in the case of indigo dyeing, it is stated that a certain amount of indigotin is always lost in the process of reduction to white indigo, and its subsequent reoxidation; the cause of the loss being obscure, its investigation would probably lead to means of preventing it which would well repay the trouble.

In every book, with the greatest amount of care and vigilance, slips and misprints will inevitably occur: thus on p. 165 it is stated that alkaloids generally have no marked alkaline reaction on phenol phthaleïn, so that the amount of acid combined in salts of morphine, quinine, brucine, aniline, urea, &c., can be ascertained by titration with standard *acid*, just as if no organic base were present: obviously standard *alkali* is intended. Similarly, on p. 234, methyl violet is described as "produced by the direct oxidation of dimethyl aniline (from dimethyl toluidine)": the production of dimethyl aniline from dimethyl toluidine is scarcely a commercial process, although the converse formation of toluidine and its homologues from methylated aniline by "intra-molecular interchange" is so. It says much for the care and attention bestowed by the author in revising that such errata are but seldom noticeable.

C. R. ALDER WRIGHT.

THE FLOATING ISLAND IN DERWENTWATER.

The Floating Island in Derwentwater: its History and Mystery. With Notes of other Dissimilar Islands. By G. J. Symons, F.R.S., Secretary Royal Meteorological Society. (London: E. Stanford, and Simpkin Marshall, and Co., 1889.)

IN this little volume, Mr. Symons calls attention to some very interesting problems connected with a curious phenomenon that can frequently be studied in our own well-known Lake District. It may at first sight seem strange that the peculiarities of this remarkable freak of Nature—for such it really seems to be—are not more widely known, or that systematic and persevering investigations, carried on by competent observers, have not long since removed all the difficulties which still stand in the way of a complete explanation of the causes to which the peculiar appearances are due. But it may at all events be hoped that—now Mr. Symons has so patiently collected and sifted the results that have been already arrived at by various investigators, and added the by no means unimportant facts he has himself observed—the reproach to British science of an imperfectly investigated and unexplained "mystery" at our very doors may at no distant date be removed.

The "history" which Mr. Symons so clearly lays before us is, briefly, as follows. As far back as authentic records can be obtained, there has appeared from time to time, in the south-east corner of the Derwentwater Lake, a small island, or islands, which, after a certain interval of time, have sunk again and disappeared. The place at which this phenomenon is exhibited is approximately the same at each reappearance—namely, a point off the mouth of the Derwent, and about 200 yards to the west of the place where the Cat Gill Beck pours its waters into the lake.

The ordinary depth of the waters of the lake at this point is about 6 feet; but the island, when it rises, appears a few inches above the level of the lake, and its surface is perfectly green with vegetation. The island is sufficiently firm to allow people to stand on it; and on one occasion a band landed on the island and played a selection of airs. The area of this island has been found to vary, on different occasions, from a few square feet up to two acres. Sometimes, several small islets have risen instead of the single one, and not infrequently the island has been found to be divided by one or more deep clefts.

Careful examination shows that the island consists of a peaty mass several feet in thickness, having its surface covered by living specimens of *Littorella lacustris*, *Lobelia dortmanna*, *Isoëtes lacustris*, and other water-plants that abound in this lake. It is also manifest that the island is merely the highest part of a great blister-like upheaval of the peat which here forms the lake bottom; and that, when this blister-like elevation subsides, the island is submerged and disappears.

When sticks are forcibly pushed into the materials composing the floating island, abundant bubbles of gas are given off, the evolution of the gas being accompanied by the production of a very perceptible odour.

During the 150 years or more, over which the records so carefully collected by Mr. Symons extend, there are nearly forty during which appearances of the island have been noticed. Sometimes, however, intervals of as much as ten years have elapsed without any appearance of the island; at other times the island has been seen for a number of years in succession; and not unfrequently it has risen and sunk several times in the course of the same year.

The island only rises in hot weather. By far the most common period for the appearance of the island has been the months of July and August; never has it been known to appear before June 5, and only once has it remained up after October 8. An examination of the temperature-records of the lake-waters and of the atmosphere in the neighbourhood points to the conclusion that the years marked by the appearance of the island are those in which the summer has been exceptionally hot.

To come now to the serious attempts which have been made to investigate the nature and causes of this interesting phenomenon. We may pass over the hasty and crude guesses of Hutchinson, Clarke, Budworth, and others, and notice first the valuable investigation of Jonathan Otley, the author of the well-known Lake-Guide. Otley had the great advantage of the advice and co-operation of the celebrated Dr. John Dalton, himself a native of the district, who analyzed the gases collected from the "floating island." Otley and Dalton's observations were made between the years 1814 and 1830.

In 1874, Dr. Alexander Knight, of Keswick, laid before the Literary and Scientific Society of that town a series of careful observations and judicious inferences concerning the floating island; and in 1876, Sir G. B. Airy took a number of bearings on the floating island, so as to fix its exact position.

Such was the state of knowledge upon the subject when the author of the present memoir took up the investigation. In August 1884 he visited the island in company with Prof. Sylvester and some other friends, and made a set of careful investigations concerning the position and size of the island, the nature of the materials composing it, the gases given off from it, and the temperature of the water around. A second visit, in August 1886, enabled the author to see the island when at the bottom of the lake.

In September 1887, Captain Wharton, R.N., F.R.S., Hydrographer to the Admiralty, obtained a section of the island by pushing a tube through the peaty mass forming the island itself down into the lake bottom. The peat was found to rest on a layer, only a few inches thick, of a diatomaceous earth.

The gases collected by Mr. Symons, Captain Wharton, and several other observers, have been analyzed by Dr. W. J. Russell, F.R.S. The results obtained are in close agreement with those of Dalton. The gas evolved appears to be a mixture, in nearly equal volumes, of marsh gas and nitrogen, with only small quantities of carbonic acid and oxygen. Dr. Russell points out that the composition of this gas is nearly identical with that of a "fire-damp" from Killingworth Colliery analyzed by Graham.

That the "mystery" in connection with the floating island of Derwentwater still remains unsolved is freely admitted by the author of the work. It would seem that during warm weather a sufficient evolution of gases takes place to cause the peaty bottom of the lake at this point to rise in a great blister. But what are the causes that give rise to this evolution of gas at this particular spot—an operation that has been repeated many times during the last 150 years—it is not easy to suggest. Equally difficult is it to assign a cause for the appearance of this phenomenon at a definite point with such remarkable persistency, while nothing of the kind has been observed elsewhere. The peculiarities of the lake-bottom at this place which may exist and may conduce to such a result do not appear to have been as yet determined.

Mr. Symons calls attention to the numerous floating islands at many different localities, which consist of accumulated masses of vegetation that have accumulated near a shore, and have subsequently broken loose. From all such cases, as he points out, the Derwentwater Island differs in three important particulars: (1) in being usually at the bottom of the lake, and only floating for perhaps one month in four years; (2) in being a part of, and remaining continuously united with, the bottom of the lake; (3) in always occupying the same spot.

It is to be hoped that this able summary of the whole evidence bearing on the question, which has been prepared by Mr. Symons, may not only attract more general attention to a very interesting phenomenon, but induce some investigator with the necessary knowledge and leisure to make such observations as are still necessary before we can hope for a complete explanation of the exact causes to which it is to be assigned.

A JOURNEY TO THE PLANET MARS.

Mr. Stranger's Sealed Packet. By Hugh MacColl. (London: Chatto and Windus, 1889.)

A WORK of fiction, founded upon scientific facts, is interesting to us, inasmuch as it may extend, to no inconsiderable degree, the scientific knowledge of its readers. Such attempts, however, to assimilate science with fiction may have an injurious effect, unless treated by one having an intimate knowledge of the phenomena which he describes, and we have to congratulate the author of this work upon his acquaintance with the Cosmos, exhibited in this account of an imaginary journey through interplanetary space.

The many means devised by that clever author, Jules Verne, for such a journey, are too well known to need any comment here. Mr. MacColl lacks the minuteness of description peculiar to Jules Verne, but nevertheless fabricates a "flying machine" that may rank with the best products of that author's ingenuity.

The principle employed is stated as follows:—

The attracting force residing in every particle of matter, and drawing it towards other particles, is capable of conversion into a repelling force.

A body, half of whose mass has had its attracting tendency converted into a repelling tendency, will have a specific gravity of zero, and if placed in a vacuum will neither rise nor fall.

If more than half the mass of a body has had its attracting tendency converted into a repelling tendency, it will rise into the air, and, passing the limits of the atmosphere, will continue moving away from the earth with a velocity for a time accelerated by terrestrial repulsion, but tending more and more towards uniformity as it proceeds.

The "flying machine" was constructed of a substance that had undergone such a conversion. By means of a regulator the resultant of the attracting and repelling tendencies could be turned in any direction, and so the velocity of the machine could be increased or diminished *ad libitum*.

It was in this machine that Mr. Stranger made his journey to the planet Mars, and the work mainly deals with Martian history, the customs of the inhabitants, and adventures and incidents *en route*. The two satellites of Mars were met, and their diameters, distance from their primary, and period of revolution are supposed to have been approximately measured by the adventurer. Having reached the planet in safety, a long description is given of the startling difference one would observe on attempting to walk upon a globe where the surface gravity was only three-eighths that of the earth.

The Marsians, Martians, or Marticoli, as Prof. Young would call the inhabitants of our ruddy brother, were, according to the author, living very happily under a form of Socialism; and food was almost as free and plentiful among them as the air which they breathed, because they had learnt to manufacture it from its chemical elements—oxygen, hydrogen, carbon, and nitrogen—which existed in abundance on their planet as on the earth. In this Utopia, not only were electric lights in every house and street, and the phonograph an instrument in common use, but the sound-figures drawn upon the revolving cylinder were used as the representation of speech, such characters being truly phonetic. It appears strange, however, that although the Martians had attained such a high degree of civilization, yet they had no knowledge of gunpowder or any explosive whatever, or of any kind of telescope, a circumstance which seems contrary to our ideas on the evolution of inventions.

The inhabitants of Mars were supposed to have come from the earth, and their transference was effected in the following manner. A sun, accompanied by satellites, in revolving at an immense distance round a larger sun passed very near to Mars and the earth, and caused them to approach one another. In the words of the writer, "The common centre of gravity of the four bodies must have been so situated as to have almost neutralized the resultant of the attraction of the earth and Mars towards their respective centres, so that on one part of the earth's surface the attraction of Mars would overcome that of the earth, and gently and slowly draw a body from its surface to its own; while in other parts the attraction of the earth would be more powerful and prevent this. The two planets must also have been so near that their atmospheres were mingled, and hence the transference did not result in the death of those who had thus to emigrate against their will."

Such an explanation as this, of some perplexing phenomena, shows an intimate knowledge of the laws of gravitation. Again, whilst on a visit to one of the small Martian satellites, a fragment of rock was broken off, and instead of at once falling down on the ground, as it would have done on the earth or Mars, it sailed slowly and gracefully away, until it came in contact with another rock several yards off, when it descended softly and gently to the ground with the motion of a falling flake of snow in a perfect calm—an imaginary incident in perfect accordance with the laws of gravitation. Many similar incidents are just as ably treated, and the description of a meteor is worth repeating here:—"Its general shape was globular, and before we had got close to it, it seemed a perfect sphere, but at this near distance it looked like a round mass of incandescent liquid covered all over with bubbling and boiling protuberances, which every now and then emitted huge jets of flaming gas, or, detaching themselves from the general mass, shot forth as globules of white shining liquid. We were, in fact, the spectators of the early formation of a little world, a sun in miniature, but resembling the sun rather as it was many ages ago than as it is now."

We might quote many other descriptions of phenomena all agreeing with acknowledged facts and rigid scientific principles. We refer to observations of the extreme blackness of the shadows cast by the rocks of the Martian satellite which was supposed to have been visited, the noiseless explosions of the meteor above described, the apparent motionlessness in space of the flying machine, in spite of its enormous velocity, the inferior attraction of Mars and its satellites, and the explanation of how men got transferred from the earth to Mars. Indeed, the work is as interesting to us as to the general reader, and as a means of disseminating scientific knowledge may be eminently useful.

R. A. GREGORY.

OUR BOOK SHELF.

The Uses of Plants: a Manual of Economic Botany, with special reference to Vegetable Products introduced during the last Fifty Years. By G. S. Boulger, F.L.S., F.G.S. (London: Roper and Drowley, 1889.)

THAT a good manual of economic botany is really wanted no one who knows anything of the subject will deny, and pending the appearance of a satisfactory book any contributions towards such an end must be accepted with thanks, always supposing that those contributions are trustworthy and intelligible. Articles by competent writers on the various products of the vegetable kingdom are to be found in encyclopædias, and occasionally special subjects are taken up and worked out by individual writers; but the great want is a thoroughly good book treating of the whole range of economic plants.

The little book before us, which comprises 224 pages, is not one that will help to such a desirable end.

The plan adopted by the author, of classifying the products under distinct heads, is undoubtedly the best; but it is not equally carried out in all parts of the work. Although, under "Food, Food Stuffs, and Food Adjuncts," we find the products divided under different sections, as starches, sugars, roots, fruits, &c., no attempt has been made to classify the individual plants mentioned under each head, whether alphabetical or scientific, while those under materia medica, oils and oil-seeds, gums and resins, are placed in some sort of scientific classification of the natural orders. Nor is the produce of one plant, though of a similar character, always to be found in the same paragraph. Thus, on p. 40, under roots and tubers, the introduction and importance of the potato are referred to, then comes a paragraph on each of the following: sweet potato, yams, Jerusalem artichokes, turnip, carrot, parsnip, beetroot, onion, parsnip-chervil, salsafy, and radish; and then, on p. 43, we have another paragraph referring to the potato, especially to the disease and the recent introductions of *Solanum maglia* and *S. Commersoni*, which would have been better placed with the account of the potato on p. 41.

On p. 59 the Souari nut (*Caryocar nuciferum*) is printed *Somari* nut, and said to be Camelliaceous. Though it is closely allied to the Camellia, it would have been more correct to call it a Ternstrœmiaceous plant. It is, however, for the meagre character of the information generally that the book is unsatisfactory. The following examples, taken haphazard, will illustrate our meaning:—

"The Coriander, the whole fruit of *Coriandrum sativum*, L., is cultivated to a small extent in Essex, but is obtained mainly from the Mediterranean and from India."

"The fruits of Angelica (*Angelica Archangelica*, L.) are used in Chartreuse, and the leaf-stalks are candied as a sweetmeat" (pp. 66-67).

Also at pp. 160-61, under "Dyes and Tanning Materials," we find the following:—"Betel Nut (*Areca Catechu*, L.) is recommended by Mr. Christy." "Canaigre is the root of the Texan Dock (*Rumex hymenosepalus*, Torrey), recommended by Mr. Christy."

"Mimosa extract was sent from Australia as early as 1823, but dropped out of notice till recently. In 1880 we imported £682,296 worth of various bark extracts" (p. 161).

Though the book is stated to have "special reference to vegetable products introduced during the last fifty years," very few dates of introduction are given, and a large number of the plants referred to were known and valued before the present century.

Examination of Water for Sanitary and Technical Purposes. By Henry Leffmann, M.D., Ph.D., and William Beam, M.A. (Philadelphia: P. Blakiston, Son, and Co., 1889.)

THIS volume contains a great deal of clearly stated information in its 106 pages. The authors have succeeded in the endeavour expressed in their preface to select trustworthy and practical processes, and to exclude the description of methods not generally employed, with other matters only remotely connected with the subject. So far as organic matter in water is immediately concerned, the "albuminoid ammonia" and the "oxygen-consuming power" are relied upon by the authors. Special prominence is also given to the estimation of chlorine, nitrogen as nitrates and as nitrites (by colorimetric processes), phosphates, dissolved oxygen, and poisonous metals. A general method of quantitative analysis for technical purposes follows, including the estimation of hardness alkalimetrically, after Hehner—rejecting soap solution altogether—and the estimation of boric acid, after Gooch, as well as the constituents that invariably receive attention. A carefully compiled chapter on the interpretation of results, and a few other matters, complete the volume.

Celestial Motions: A Handy Book of Astronomy. By William Thynne Lynn, F.R.A.S. Sixth Edition. (London: Edward Stanford, 1889.)

THIS is the sixth edition of an interesting little book, which explains briefly the principal facts relating to the motions of celestial bodies, and to the dimensions of those belonging to our own system. The information has been brought up to date, and an addition of a chapter on "The Calendar" has been made. In the chapter on the sun we are told that "the solar spots are produced by tearings open of some of the luminous envelopes which surround the sun, so that we see in them to a depth below that of the solar surface." To an ordinary reader this statement would be rather misleading, since no mention is made of the absorption of the sun's light by the descent of the cooler particles on to the solar surface from the upper regions of its atmosphere, the spots thus being made to appear dark and not bright. In chapter x. a short reference is made to the refraction, propagation, and aberration of light, while in chapter xii. we have a brief sketch of the history of astronomical discovery. The book concludes with an explanation of astronomical and technical terms.

Science Examination Papers. Part I. Inorganic Chemistry. By R. Elliot Steel, M.A., F.C.S. (London: George Bell and Sons, 1889.)

THIS work, intended for teachers, consists of a series of examination papers arranged in a progressive and logical order. It is divided into two parts, theoretical and practical, and is written, as the author tells us, "not as a cram-book, but as a means of testing the student's knowledge and progress." The first part treats of questions on hydrogen, oxygen, ozone, &c., followed by a set of general questions on the above, concluding with a collection of papers taken from various examinations, such as the London Matriculation, Science and Art Department, Oxford and Cambridge Locals, &c. Part II. deals with questions on simple and mixed salts and elementary quantitative analysis. The work is one of the "School Examination Series" edited by A. M. M. Stedman, and should prove serviceable to those teaching natural science in many of our schools.

A Course of Easy Arithmetical Examples for Beginners. By J. G. Bradshaw, B.A. (London: Macmillan and Co., 1888.)

THIS is a very elementary book, suitable for the use of young boys. It consists of a collection of simple arithmetical examples. The first part deals with examples in simple and compound addition, subtraction, multiplication, division, and reduction. Part II., which has been in use for over a year in the Junior School at Clifton, treats entirely of vulgar fractions; Part III., of decimals, practice, and proportion. The various tables used throughout are given at the beginning, and the results of all the examples are collected together at the end.

The Prospector's Hand-book. By J. W. Anderson, M.A., F.R.G.S. Fourth edition. Pp. 145. (London: Crosby Lockwood and Co., 1889.)

THE general plan of this book was described on a preceding occasion, so that at present it is only necessary to notice the changes in the new issue. The work, we are told, has been thoroughly revised and enlarged. The enlargement consists of about eight pages of descriptive matter, mainly referring to South Africa; but the results of the thorough revision do not appear to be very considerable. Nearly all the mistakes and ambiguities in the original descriptions of metallic minerals are unchanged. The author calls attention to an addition descriptive of aluminium and its ores, from which we gather that bauxite is a ferruginous clay, a statement that is both original and incorrect. On pp. 94 and 96, one ton is said to contain 29,166 troy ounces, while in the table, on p. 121, 1 per cent., in an assay return, is given as equivalent to 326 ounces 13 dwts. 8 grains per ton. The latter statement is right, the former one is wrong, but the author does not attempt to explain the discrepancy. Perhaps he will do so in the next issue.

H. B.

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.*]

Coral Reefs.

WITH reference to Captain Moore's two difficulties, I have to say:—(1) The position of banks around islands depends, in my opinion, on the nature of the rocks; loose material, or easily disintegrated rock, may be found either on the lee or weather side of an island. There are many examples of these banks in all positions around islands where there are no coral reefs. (2) I do not think it is the case that corals reach the surface simultaneously on all sides. What Captain Moore refers to as sunken reefs is good evidence that they do not. The great uniformity in the breadth of the reefs in some regions is, according to my view, due to the play between the forces secreting and depositing carbonate of lime, and those engaged in its disintegration and solution whenever the organisms have died. Reefs are very often non-continuous, as Captain Moore himself points out in the case of the Barrier Reef of Australia. This, too, I have explained in the same way, but taking into account local conditions. I cannot admit Captain Moore's supposition about the filling up of the lagoon around Solo, nor his explanation of the bank to the west of Ono. I have no charts with me here, so cannot at present refer to the other illustrations he has given.

Grangemuir, Pittenweem. JOHN MURRAY.

An Earthquake?

ON Friday, July 5, the inhabitants of Lyme Regis were much astonished by some noises, which took place at intervals between 11 and 11.15 p.m., and which there seems good reason to believe were caused by an earthquake. In three houses the occupiers thought that heavy pieces of furniture were being moved about, which was of course found not to be the case; and in another the inmates thought at first that something was wrong with the kitchen boiler. The noises observed consisted of a distant rumble which grew nearer till at last the windows of the houses rattled, and in some cases distinct vibrations of the houses were felt. Some have supposed that these noises were caused by guns at sea, but this seems impossible, because (1) the rattling of the windows occurred after the distant rumble, and not simultaneously as would have been the case with guns; (2) a gentleman who has had much experience in guns and firing, has declared that the noise was not like guns; (3) after making enquiries we have been unable to discover that any firing at sea took place that night; (4) although the night was still, a heavy ground swell was observed. These phenomena have not received any notice as far as we know in the public press, and it seems a pity, if an earthquake, as we believe, really took place, that there should not be some record of it.

Lyme. A. R. SHARPE.

The Excursion to the Volcanoes of Italy.

THANKING you for noting the intended excursion of geologists to the active and extinct Italian volcanoes under the auspices of the Geologists' Association and Geological Society of London, I would like to draw the attention of your readers to the remarkable changes at Stromboli which have lately occurred. New eruptive mouths have opened, and there has been an outflow of lava, a phenomenon so far unknown (so far as recorded) from 2000 to 3000 years. There is an uncertain reference to such an occurrence, but the change at Stromboli from Strombolian to Vesuvian activity is remarkable. I am also informed that the eruption of Vulcano still continues with paroxysms of greater activity. Thus the excursionists will have the advantage of seeing changes that, even for a constant resident in such a region, are rare. H. J. JOHNSTON-LAVIS.

Naples, July 15.

Seismology in Italy.

I WAS glad to see that Prof. Grablovitz had laid claim to attention for some of his other memoirs which I had not at that time seen, and which are of much value. I would especially draw the attention of seismologists to his study of the relationship of temperature and outflow of a thermo-mineral spring at Porto d'Ischia to the tides and barometric pressure.

In my article I only reviewed those memoirs placed in my hands by the Editor of NATURE, or sent to me privately. I may, however, say that as near as possible a complete review of all the papers on seismology and vulcanology published during 1888 is being prepared by me for the *Annuaire Géologique Universel* of this year. I should therefore be glad to receive any other papers on those subjects, that have not been sent to me, as soon as possible. H. J. JOHNSTON-LAVIS.

Naples, July 15.

The Earthquake of Tokio, April 18, 1889.

READING the report on this earthquake in NATURE (June 13, p. 162), I was struck by its coincidence in time with a very singular perturbation registered by two delicate horizontal pendulums at the Observatories of Potsdam and Wilhelmshaven. These instruments, which represent, with some modification, Prof. Zöllner's horizontal pendulum, were established in March 1889, for studying the slight movements of the ground. The motion of the pendulum, which is left to oscillate freely whenever its equilibrium is disturbed, is registered by the same photographic method as that employed for magnetic observations. The pendulum is in the plane of the meridian, so that any shock, the direction of which is not in this plane, will produce oscillations of the pendulum, diminishing gradually, if it is left undisturbed after the shock. The pillars supporting the instruments are fixed in a depth of 1 metre below the ground of the cellar which was chosen as a suitable place for the erection of the instrument.

During the three months from April to June, the disturbance of April 17, 18h. G.M.T., was the most remarkable which occurred The following readings of Greenwich mean time, which are best explained by the accompanying figures, are taken from the original photographs; it must, however, be mentioned that the small scale of 11 millimetres per hour does not allow a very accurate determination of time, and that an error of one minute or two is quite probable.

(1) *Potsdam.*—1889, April 17. From 5h. until 17h. 21m., great steadiness of image.

h. m.	
17 21	First traces of disturbance.
17 39	Beginning of small oscillations.
17 54·3	Motion *suddenly* increases and reaches its maximum at
18 1	Amplitude of oscillation 154 millimetres. The amplitude then suddenly diminishes.
18 43 18 58 19 45	Maxima of oscillation.
20 0	Perfect steadiness of image.

(2) *Wilhelmshaven.*—Here, also, the image is perfectly steady until 17h. 30m.

h. m.	
17 30	Beginning of small oscillations.
17 48–17 51	A short interval of perfect steadiness.
17 51	The movement *suddenly* increased, and as the light is not strong enough to mark the single oscillations, the image disappears until
18 38	when the principal disturbance reaches its end.
18 51 19 6 19 22 20 2	Maxima of small oscillations.
20 7	Perfect steadiness.

If we compare these dates, it seems most probable that the moment which shows a sudden increase of motion, and is best marked on the curves, may be considered as the beginning of the principal disturbance. We thus have—

For Potsdam ... ... 17h. 54·3m. }
For Wilhelmshaven... 17h. 51m. } Mean, 17h. 52·7m.,

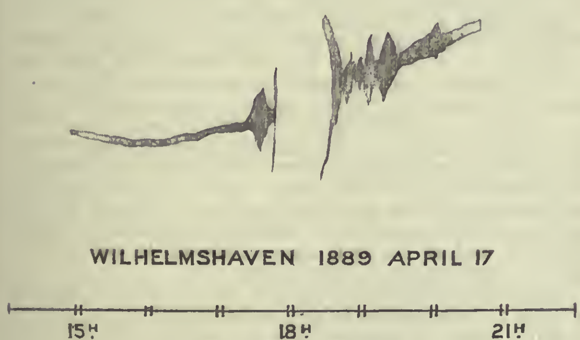
which, considering the error of the readings, may be taken as one and the same moment.

The beginning of the earthquake of Tokio was observed at 2h. 7·7m. Tokio M.T. The difference of longitude (taken from a map) being 9h. 19·3m. E., we find that the shock occurred at 16h. 48·4m. G.M.T. on April 17, and thus it took 1h. 4·3m. to travel across the body of the earth.

Taking the following longitudes and latitudes—

Tokio	139° 50′ E.,	35° 44′ N.
Potsdam	13 4 ,,	52 24 ,,
Wilhelmshaven	8 9 ,,	53 32 ,,

1889 APRIL 17. GR.M.T.
POTSDAM.



GR. MEAN TIME.

and neglecting the ellipticity of the earth, we find the following distances:—

Tokio to Potsdam	8221 kilometres.
Tokio to Wilhelmshaven... ...	8307 ,,

Dividing the mean 8264 by 3858s., we find a velocity of 2142 metres of propagation on the straight line connecting Tokio and a place between Potsdam and Wilhelmshaven, and consequently the shock ought to have been observed at Wilhelmshaven 40s. later than at Potsdam.

The above value of velocity is between the values found by Milne from seismic experiments, viz. 900-1400 metres for different kinds of rock, and by Abbot from the effect of dynamite explosions, viz. 2800 metres. We may therefore safely conclude that the disturbances noticed in Germany were really due to the volcanic action which caused the earthquake of Tokio.

Potsdam, July 5. E. VON REBEUR-PASCHWITZ.

P.S.—I add a list of the most remarkable disturbances noticed during the course of the observations. Unfortunately, the working of the instrument at Wilhelmshaven was often disturbed by the effects of an excessive dampness in the cellar. The time is G.M.T. as above.

1889, April 5.—A day of great steadiness. A small perturbation begins at 9h. (Potsdam) and 9h. 5·4m. (Wilhelmshaven). It is divided by a short time of steadiness, 9h. 11·4m. (Potsdam) and 9h. 16·8m. (Wilhelmshaven).

April 8.—A fine disturbance begins at 16h. 45·6m. (Potsdam) and 16h. 47·4m. (Wilhelmshaven).

April 15.—A day of remarkable unsteadiness; the principal perturbation at both places lasts three hours, and lies between 7h. and 10h. It is impossible to determine a certain phase.

April 25.—A perturbation from 16h. 48m. to 18h. 12m. at Potsdam. No photograph obtained at Wilhelmshaven.

April 28.—An earthquake, consisting of one principal shock, apparently took place at 21½h.; the times noted are 21h. 34·8m. (Potsdam) and 21h. 36·6m. (Wilhelmshaven).

May 21.—A pretty large disturbance at Potsdam, lasting from 10h. 33m. to 11h. 6m., interrupted by a moment of rest at 10h. 42m. No photograph at Wilhelmshaven.

May 25.—Two very remarkable disturbances at Potsdam—7h. 9m. and 10h. 42m.—each lasting 1h. No photograph at Wilhelmshaven.

May 26.—A disturbance noticed at Potsdam, at 9h. 24m. No photograph at Wilhelmshaven.

May 30.—At Wilhelmshaven, two shocks are noticed—8h. 18·6m. and 9h. 24m.—which are probably connected with the English earthquake of this day. Perfect steadiness at Potsdam.

May 31.—A disturbance of earthquake-like appearance. Time of beginning, at Potsdam, 8h. 48m.; at Wilhelmshaven, 8h. 44·4m.; the latter time being rather uncertain, on account of the faintness of the curve.

I hope that one or other of these facts may prove to be of interest to seismologists.

On the Phenomena of the Lightning Discharge, as Illustrated by the Striking of a House in Cossipore, Calcutta.

DURING a heavy thunderstorm which passed over Calcutta about 5.30 p.m. on Saturday, June 8 last, the house of Conductor W. Viney, at Cossipore (a suburb of the city), was struck by lightning, and I have thought that a description of the phenomena connected with it might perhaps be worth placing on record in the columns of NATURE.

I was myself watching the storm from the veranda of my residence about 300 yards distant, and observed that the discharge in question was one of extreme violence. I visited the scene of the accident within a few hours, with Mr. Viney's permission taking the notes from which this account is prepared; and, owing to the exceptional opportunities for observation which obtained in this case, have been able to secure trustworthy statements as to the appearance of the discharge, and further, by inquiry, to satisfy myself upon one or two points which I believe to possess considerable scientific interest.

The house which was struck is large, square, and flat-roofed, and is occupied by three foremen employed in the Government Shell Factory adjacent: it is provided with a lightning-conductor projecting 8 or 9 feet above the roof-level, and situated near to one end of the building, but apparently unconnected with any other portion of the roof. It is possible that a portion of the discharge passed harmlessly away by the conductor, but of this I have no evidence, positive or negative. The lightning entered Mr. Viney's portion of the house by a corrugated iron covered hatchway standing 6 feet high at the corner diagonally opposite to the conductor, and about 70 feet distant from it in a direct line: leaving the iron cover and its wood lining untouched, it broke through the masonry, hurling portions of the brickwork to a distance of 25 feet along the flat roof; then, bridging over 3 or 4 feet of air, it reached the iron hand-rail of a spiral wooden staircase leading into the house. Incidentally, it may here be noted that this house is the nearest to the factory, which bristles with lightning-conductors at every available point; and, further, that the charged cloud would in its course pass over the portion struck before it could reach either the factory conductors or that on the house itself. Passing down the hand-rail for 11 feet, it reached a point at which metallic continuity ceased, owing to the interruption of the hand-rail; here it appears to have divided, a portion leaping along 5 feet of the wall and stripping off the plaster in patches, until it reached the second section of the hand-rail; through this it passed harmlessly, and then flew through 2 feet of space to an iron rod resting in the corner of the wall, perforating a wooden "stair-rise" on its path. The other portion discharged through about 7 feet of space in the angle of the wall direct from an iron standard, supporting the first hand-rail, to the iron rod; here, reuniting with the other portion, the whole current broke through the wall into an adjoining bedroom, and thence through the wood flooring to a sitting-room beneath. It may be observed that the spiral staircase at one time communicated with the ground-floor, but has since been filled in and covered over; there is no evidence, however, to show that any portion of the charge made earth in this direction. Within a few feet of the point where the ceiling was penetrated (but round a corner) is a broad staircase with a wooden handrail, supported by uprights of iron rod placed about 4 or 5 inches apart from top to bottom; but this path was not taken. Having penetrated to the sitting-room, as above described, it appears to have passed in a direction precisely opposite to that ultimately taken, and to have circled in a spiral manner around one of two brick pillars at that end of this room, and having laid bare the bricks in several places, but chiefly at a height of 4 feet from the ground, it passed across the room in which Mr. Viney was sitting with seven members of his family and friends, and upwards to the ceiling at the opposite end. Breaking through the ceiling (which is, as usual in these houses of wood, not of plaster), it burst up the boarding and singed the matting above, and again descended, but now into the dining-room on the other side of a partition wall. Here, darting diagonally downwards to the opposite wall and stripping off a large area of plaster in one place, it made for an electric bell suspended in the centre of this wall, fused the contacts, and apparently passed along the connecting wire to the battery, of which two out of six cells were shattered, and finally escaped through a return wire to a cookhouse 30 yards distant in the compound. Strangely enough, these wires, although thin, are not fused, which serves to strengthen the opinion that only a portion of the charge penetrated at least into the lower rooms, even if the whole entered by the spiral staircase.

The path of the discharge from the first entrance into the sitting-room to the final exit by the bell-wire is somewhat inexplicable—especially the circuit of the brick pillar, which is said to be of solid masonry, with no iron core; it is true that a sewing-machine was standing on the further side of the pillar, but although within a few inches of the patch denuded of plaster, it appears to have been unaffected. Again, there were several metallic objects in the room—an iron chair close to the abovementioned pillars, and a square horizontal piano with the strings parallel to the line of discharge, yet both were untouched; the occupants of the room also were practically in the same line, but were perfectly uninjured. Then, too, there was apparently nothing to lead the lightning through the ceiling boards to gain access to the dining-room in preference to an open door a few feet distant. And, lastly, it did not pass across the latter room in a direct line to the electric bell, but struck the wall about 5 feet away, tearing away the plaster and leaving upon the bricks a netted marking recalling the branching discharges of a torrent of sparks from an induction-coil or Wimshurst machine; near this point, but a few inches to one side (the bell side) and in front, was a pendent iron chain, which may have determined the charge in that direction, but shows no sign of having been touched; and immediately beneath the spot through which the lightning entered the room was standing a member of the household, who also escaped with a severe shock to the nerves and a temporary tingling sensation. Attached to the affected pillar in the sitting-room was a cuckoo clock, and this alone in that room appeared to suffer; the weight chain was taken in transit, and the clock began vigorously to chime, which it has refused to do ever since.

Mr. Viney happened to be facing in such a direction that he could watch the progress of the discharge. He describes the effect as that of an intensely brilliant ball of yellow fire, about 6 or 7 inches in diameter, which passed from one end of the room to the other at a pace just sufficiently slow to allow it to be readily followed by the eye; about half-way across, it appeared to be momentarily checked, and then, seeming to burst with a deafening report which shook the whole house, it scattered and passed onward.

About certain points he is absolutely certain: there was no premonitory warning, no sound of a brush discharge or odour of ozone, the first intimation being the entrance of the fire-ball itself. Again, the direction taken was from the staircase to the bell (that is, from cloud to earth), and the direction was uniform, and no second ball was seen to enter from the opposite side to meet the first and so produce the apparent explosion, nor after the concussion was there any other phenomenon than the passing on of the ball.

Again, it has long been known that the passage of high tension discharges through mixtures of oxygen and nitrogen induced combination of these elements; I therefore asked Mr. Viney as to the after appearances, and as to the presence of unusual coloured gases, or of a suffocating sensation. He at once said that the whole house seemed to be filled with an orange-coloured gas (mixed, of course, with clouds of dust), the breathing of which was perfectly stifling, and was equivalent to inhaling the fumes from burning sulphur. I have since asked him to report upon a sample of nitrogen tetroxide highly diluted with air: he declared that the gas in his house was of a brighter orange shade, and of a somewhat similar yet not identical odour; on presenting him, however, with a stronger mixture, he was quite confident that both in colour and in smell the two gases were identical. I am here practically confined to my own library for books of reference, but am not aware that this observation has actually been made before, although, as above stated, theory has long since ruled that such a reaction must occur during the electrical discharges of a thunderstorm. But the proof is here not only that the reaction does occur, but that a very large proportion of the oxygen in the atmosphere immediately surrounding the path of the flash must be converted into oxides of nitrogen.

The appearance of the fire-ball was only within the house. The discharge as seen from my position appeared as an almost straight ribbon of light; owing unfortunately to intervening trees, the flash could not be traced quite to the house, or the question as to the branching of the lightning on entering the house might have been definitely answered.

Several points seem to be thus clearly brought out, *e.g.*, *inter alia*, (1) the futility of partial lightning-conductor protection; (2) the apparently erratic nature of the discharge; (3) the apparent conversion of the instantaneous discharge of ribbon-lightning into the slower travelling modification of globe-lightning; (4) the formation of large volumes of oxides of nitrogen by the lightning discharge.

The above recorded observations might appear to add colour to an authoritative statement on p. 629 of Nystrom's "Pocket-book of Mechanics" (Philadelphia and London; revised and enlarged edition of 1886), where, in speaking of certain explosions, the author (or at least the printer) lays down that "the explosion of nitro-glycerine is instantaneous like that of electricity passing between two points, decomposes a small portion of the air, and explodes the nitrogen by concussion, which makes the electric spark. Thunder and lightning are explosions of a kind of nitro-glycerine formed by electricity in the air." We might even be led to indorse this both novel and ingenious explanation could we but bring ourselves to reverse existing notions as to the properties of matter and the laws of thermochemistry, and, at the same time, reconstruct the principles of electrical science upon a suitable basis.

The accumulation of authenticated cases such as the above is of value in throwing more light upon the vagaries of the "electric fluid" at enormous potential, and in helping to elucidate the laws under which it acts, and hence the laws which should govern the protection of buildings; and it is in the hope that this account may form a small item in the mass of evidence, that I venture to forward it for publication.

WALTER G. MCMILLAN.
Chemical Department, Shell Factory,
Cossipore, Calcutta.

The Circulation of the Atmosphere over the Equator.

ABSENCE from home has prevented my seeing Mr. Foulger's letter on this subject till to-day.

The observations on the upper winds over the doldrums, which I have described in NATURE, were taken in about 5° N. latitude and 28° W. longitude, and the whole section of the trades and doldrums lay in a line drawn from St. Vincent to Rio Janeiro.

When I stated that "low clouds from south-east flew over the north-east trade up to 15° N.," I meant to say that while the surface-wind from the doldrum to 15° N. was the north-east trade, the low or middle layers of cloud moved from south-east, all along the line of the section above noted.

Unfortunately I am unable at present to give a general scheme of the circulation of the atmosphere, though I have worked at the subject for years; and my recent observations in the Andes, from Peru to Cape Horn, throw much new light on the question.

What we do know is that the surface trades either die out at the doldrums, or unite into one moderate east current; that the low and middle currents over the doldrums are very variable, but that the wind at these low and middle levels—say 2000–20,000 feet—come usually from the south-east over the north-east trade, and from the north-east over the south-east trade; and that the highest currents—over 20,000 feet—move from east over the doldrums, from south-west over the north-east trade, and from north-west over the south-east trade. We also know that the high-level south-west and north-west winds near the equator gradually descend to the earth's surface about 30° N. and 30° S. respectively.

What we do not know is the relation of the south-east low and middle current over the north-east trade to the south-east trade on the other side of the equator, nor have we yet discovered what becomes of this middle current in the northern hemisphere. In like manner the origin and ultimate destination of the middle north-east current over the south-east trade is equally a matter for future research.

Of course, all meteorology turns round the general circulation of the air through the heating of the equatorial regions, but what I maintain is that the simple scheme which assumes nothing but an upward current over the doldrums and a return current towards each Pole is not confirmed by observation. The reality is more complex, for the centre of the high doldrum current is from the east, but diverges at the edges from south-west and north-west.

The discovery of the true nature of the general circulation of the atmosphere from the equator to the Pole—apart from any theoretical considerations—is a matter of so much importance for the future of meteorology, that I hope all future travellers across the equator will note carefully the direction of the clouds in low latitudes. I know this is somewhat difficult on board ship for want of a steady point of reference; but those whose zeal prompts them to look out between 5 and 6 in the morning, and from 6 to 7 in the evening, will usually find the moon, or some bright star, by means of which the direction of the cloud-motion can be accurately determined. Above all things, the relative, and if possible the actual, level must be carefully noted; and the observations should not be recorded as we so often see—wind north-east, clouds south-west—without any indication as to whether the south-west current is at a low, middle, or high level.

RALPH ABERCROMBY.

21 Chapel Street, London, July 22.

Changed Environment.

IT is generally known that the English sparrows were introduced into the United States on the supposition that they were insect feeders, and would protect our trees from the canker-worm. For the first time in my remembrance, I have seen one attack a caterpillar this summer. Their usual food appears to be the seeds found in horse-manure on the streets. They are now universally conceded to be an unmitigated nuisance, not doing their assigned work, and preventing others from doing it. They usurp the place of the more charming native birds, the blue-bird, the wren, and the Baltimore oriole, once common in our cities. Still, we have to confess that the sparrows are interesting little creatures, aggressive and pugnacious.

I was lately told of a circumstance, which I can myself now confirm. An "American robin" was seen watching a beetle, known here as the "June bug," that had just emerged from the ground. He tossed him about with his bill, and was closely watched by a sparrow who had alighted about a foot away. Seeing the latter, the robin at once attacked him, when the sparrow made a dive between his legs, seized the beetle and flew away. A robin rarely hunts for earth-worms, of which robins are especially fond, without being followed by one or more sparrows. These often get the worm for which the larger but less agile bird has laboured.

Another matter suggests itself to me. Mr. Wallace in his new and delightful book on "Darwinism," which reawakens one's old enthusiasm, says that many plants live "not where they must, but where they can." The natural habitat does not always appear to be the best. Thus, *Lobelia cardinalis*, so common in our Rhode Island woods, is always found on the brink of running streams, or where these *have* been, or near water. It is in such sense aquatic. But, removed to a garden, it will grow vigorously and multiply astonishingly exposed to full sunlight and in ordinary loam. Indeed, the plants prefer to escape from the beds into the gravelly paths. They will overrun a garden.

Aster Novæ-Angliæ is not one of our most abundant asters, but in a garden it will crowd out all else. The seedlings spring up even in the dry soil loved by *Plantago major*. *Viola pedata*, which grows naturally in sand, will flourish and increase in size by cultivation, becoming as handsome as a pansy. *Corydalis glauca* grows in nature on hot exposed rocks and cliffs; it will grow larger and better, and set seed abundantly, in rich loam.

I could multiply instances of such changed environment where the result was beneficial. W. WHITMAN BAILEY.

Brown University, Providence, Rhode Island, U.S.A., July 2.

Lamarck *versus* Weismann.

I SHOULD like to call the attention of those interested in organic evolution to a remarkable passage in Mr. Wallace's recent volume on "Darwinism." This work is throughout an argument in defence of Darwinian principles, in their original unmodified form as stated in the "Origin of Species," in opposition to all recent criticism or development of those principles. And yet on p. 129 the author publishes the following passage:—"Now the eyes of these fish (Pleuronectidæ) are curiously distorted in order that both eyes may be on the upper side, where alone they would be of any use. It was objected by Mr. Mivart that a sudden transformation of the eye from one side to the other was inconceivable, while if the transit were gradual, the first step could be of no use since this would not remove the eye from the lower side. But, as Mr. Darwin shows by reference to the researches of Malm and others, the young of these fish are quite symmetrical, and during their growth exhibit to us the whole process of change. This begins by the fish (owing to the increasing depth of the body) being unable to maintain the vertical position, so that it falls on one side. It then twists the lower eye as much as possible towards the upper side; and the whole bony structure of the head being at this time soft and flexible, *the constant repetition of this effort causes the eye gradually to move round the head till it comes to the upper side.* Now if we suppose this process, which in the young is completed in a few days or weeks, to have been spread over thousands of generations during the development of these fish, those usually surviving whose eyes retained more and more of the position into which the young fish *tried to twist them*, the change becomes intelligible."

A Lamarckian could accept the above passage almost without altering a word. The words I have italicized describe with absolute precision the muscular effort of the fish as the active cause, both of the individual and the ancestral metamorphosis. And yet, in chap. xiv., Mr. Wallace expresses his acceptance of Weismann's dogma of the non-inheritance of acquired characters with the words, "We cannot therefore accept any arguments against the agency of natural selection which are based upon the opposite and equally unproved theory that acquired characters are inherited; and as this applies to the whole school of what may be termed Neo-Lamarckians, their speculations cease to have any weight." J. T. CUNNINGHAM.

July 19.

Bored Stones in Boulder Clays.

STONES bored by *Pholas* and *Saxicava* are by no means rare in the shelly "Basement clay" of East Yorkshire, and I have occasionally found examples in which the shells remained in the borings surrounded by fossiliferous sand, just as described by Mr. T. Mellard Reade from the Lancashire area. These stones are generally limestones of various kinds—Carboniferous, Magnesian, Jurassic, or Cretaceous—and the diversity of their origin seems to show that they have first been scattered over a shallow sea-bottom by floating ice, and afterwards perforated, but I do not think that they can be taken as proof of the marine origin of the boulder clay in which they now lie.

The same boulder clay contains many detached valves of bivalve shells, and these very frequently still hold a pinch of sand under the umbo, though themselves firmly embedded in hard clay; and in one case I found, under such conditions, a perfect shell (*Tellina balthica*), with valves united, enclosing similar sandy material.

It seems to me very difficult to explain by any theory of floating ice how this sandy matrix could have been preserved in the holes of the stones and under the valves of the shells, while it is easy to understand how this might take place through the agency of land ice advancing over a sea-bottom.

Before the culmination of the glacial period, while yet the ice was encroaching upon the sea-bed, and long before it had reached its greatest extension, there must have been a vast quantity of floating ice in the waters, which would drop stones and other material over the sea-bottom; and there must also have been a great extrusion of matter from the various glaciers. And as the ice advanced this material would necessarily become part of the *moraine profonde* of the glacier, and would be more or less mixed up with the old sea-bottom, but the resulting boulder clay could scarcely be called marine. G. W. LAMPLUGH.

Bridlington Quay, July 15.

Mr. Lydekker on Phenacodus and the Athecæ.

IN his article on *Phenacodus primævus* in NATURE of May 16 (p. 57), Mr. Lydekker expresses his disbelief in my opinion that that animal is nearly related to the immediate ancestor of the line of the Quadrumana, and of man. I am somewhat surprised at the positiveness of Mr. Lydekker's expression, as he must be aware of the difficulties that still surround this part of the question. What may be known about it is as follows:—

First, I have always been careful to avoid the assertion that the genus *Phenacodus* was in the direct line of descent of man. When I first traced the ancestry of the Quadrumana, I indicated the sub-order Condylarthra as its source (*American Naturalist*, 1885, p. 347; "Origin of the Fittest," 1887, p. 343), not the genus *Phenacodus*. On a subsequent occasion I restricted the range of probable ancestry to the family *Phenacodontidæ* (*Naturalist*, 1888, p. 663). In the advertisement to which Mr. Lydekker refers, I say of the *Phenacodus primævus*, "Representative of type believed to be the ancestor of all hoofed Mammalia, monkeys, and man." Mr. Lydekker's reference to this advertisement is slightly different.

Second, Mr. Lydekker objects to regarding *Phenacodus* as within the ancestry of the lemurs and man, because it appears to have no clavicle. To this proposition two replies may be made. The first is, that it is by no means certain that it had no clavicle. The second is, that if it had none it is not certain that that fact would exclude it from the ancestry of the Quadrumana; certainly it would not exclude some near ally of the same family or sub-order which possessed a clavicle. On these points I remark further.

Third, nothing can be determined from the specimens as to whether the *Phenacodus primævus* or *P. wortmani* had clavicles or not. None were found, but this part of the skeleton was disturbed in both specimens. Thus the clavicles, if present, may have been like those of some Carnivora and Rodentia, connected with the manubrium sterni and scapula by soft tissue only, and so have been readily lost.

Fourth, the presence or absence of clavicles is not important in a systematic sense. It is not available as a definition in the orders Edentata, Rodentia, Insectivora, and Carnivora, where, as is well known, it may be present, rudimental, or absent. And in the phylogenetic history of a line, I see no reason why clavicles might not lose and later recover their osseous tissue under suitable stimulation.

Finally, I believe that the Condylarthra are in the direct line of ancestry of the higher apes, so long as no better objections can be found than those raised by Mr. Lydekker. Another objection exists which he has not pointed out; viz. the absence of anapophyses of the vertebræ. But this objection loses much point when we remember that anapophyses are also wanting from the vertebræ of the anthropoid apes and man. What their status was in the anthropoid lemurs (*Anaptomorphus*) we do not yet know. Moreover, a trace of the anapophysial structure does exist in both species of *Phenacodus*, as a fold continuous from the posterior border of the neural arch over the centrum. As regards the clavicle, it is highly probable that it is present in some of the genera of the Condylarthra, and even of the *Phenacodontidæ*, such, for instance, as *Protogonia*, but we know too little of the structure of the skeletons of several allied genera, to enable us to determine the points in question. On the presence or absence of anapophyses in such genus of Condylarthra will depend the solution of the question whether the descent of man passes through *Anaptomorphus* or *Adapis*, or some other undiscovered form of Quadrumana, to the anthropoid apes.

While on this subject I refer to Mr. Lydekker's reference to my term Athecæ (Testudinata), as "ungrammatical." He declares that the grammatical form should be Athecata. Now, while the latter expression is perhaps grammatical, it is not more so than the one which I elected to use. It is probably well known to Mr. Lydekker that scientific names are written in Latin, and not in Greek. The singular Atheca, although derived from the Greek, becomes Latin by scientific use and usage, and is declined, genitive *æ*, and nominative plural *æ* also. See Latin words derived from θήκη, as Bibliotheca, -æ. I used the substantive form, which is more usual than the adjective, in making scientific names. E. D. COPE.

Philadelphia, July 1.

Systematic Position of the Characeæ.

THE position in a natural system of classification of this small and strongly-differentiated group of aquatic plants has been so long a subject of controversy, that any additional light upon it will be welcome to vegetable physiologists. I therefore desire to call the attention of my fellow-botanists to the remarkable paper by M. Guignard, "On the Development and Constitution of the Antherozoids of Cryptogams," in the early numbers of the new botanical journal edited by M. Bonnier—the *Revue Générale de Botanique*. It is true that these observations only confirm the earlier ones of Thuret; but the care with which M. Guignard has worked out the subject, and his beautiful drawings, tend to emphasize the results previously obtained.

No one who compares the drawings of the antherozoid of *Chara fragilis* in Pl. 2 with those of *Fellia epiphylla* in Pl. 3 can fail to be struck with their remarkable resemblance. Each is a long, corkscrew-shaped body, with a pair of very long and slender vibratile cilia attached to its anterior extremity. The mode of development of the antherozoid is also the same in all essential particulars in both cases, and is thus described by M. Guignard. The body of the antherozoid proceeds from the nucleus of the mother-cell, and moreover gives all the micro-chemical reactions of nuclein. The vibratile cilia are derived from the cytoplasm. A thickening band first appears on the surface of the nucleus, and grows longer and longer, forming eventually a kind of beak, and the whole nucleus becomes twisted spirally as it increases in length. As soon as the outlines of the anterior extremity of the filament are discernible, the two cilia may be perceived in the thin layer of hyaline protoplasm which is nearest this extremity. Later on, the cilia, which at first lie close to the filament, become separated from it, and the rest of the protoplasm gradually disappears, being absorbed and used up for the nutrition of the antherozoid, so that only a few granulations are left on the posterior extremity of the filament. The only difference of any importance between the antherozoids of Characeæ and those of Muscineæ is the absence in the former of a vesicle formed from the cytoplasm of the mother-cell.

If now this is compared with the figures (Pl. 5) of the antherozoids of *Fucus serratus*, and the account of their mode of development, it will be seen how wide are the differences in many essential points between the corresponding processes in Characeæ and in the higher Algæ. These facts seem to me strongly to corroborate the view which I have on several occasions ventured to bring forward, and to support by other considerations, that the Characeæ are more nearly related to the Muscineæ than to the true Algæ.

I may mention in conclusion that M. Guignard adopts the revised terminology which I have advocated, of *antherozoid* instead of "spermatozoid" for the male fecundating organs of most Cryptogams, and of *pollinoids* (or rather *pollinides*) instead of "spermatia" for the corresponding organs in the Florideæ.

ALFRED W. BENNETT.

Make-believe.

I CAN well believe in Sally meaning a joke. Animals have a keen sense of "making believe" which is the essence of *play*. A child's first game is bo-peep—a make-believe. When a pair of friendly dogs have a jolly tussle, they make believe to engage in deadly combat.

A striking instance of this occurred to me some years back. I gave a dead mouse to a kitten. It was the first time she had seen one, and she sniffed at it inquisitively before deciding on tossing it about. A pair of slippers lay on the floor. She dropped it into one of them, and *immediately* proceeded to look for it most zealously in the other slipper, till I took up the first, which contained her booty; then she showed that it was no real lack of memory that had sent her on the bootless search.

The law allowed to game, when hunted for recreation, is perhaps the most marked evidence of the make-believe element which is to be found in the play of civilized adults.

Dublin, July 16. MARCUS M. HARTOG.

Dogs and Fire.

AN unrecorded type of the pluck of the fox-terrier was demonstrated to me recently. A young dog two or three years old, the property of Mr. Doyle, of Loretto Terrace, Bray, goes for fire with as much zeal as any of his race go for rats. When a newspaper thoroughly ablaze is thrown down, he stamps upon it with frequent short rushes till it is extinguished, and then worries the scorched remains before asking for a fresh opportunity. He gets excited and keen on being shown a crumpled newspaper or a match-box.

The possibility thus shown of educating dogs to tackle fire gives additional point to my friend Dr. Sigerson's published suggestion to use dogs as companions to night-watchmen, based on their keenness of scent. MARCUS M. HARTOG.

Dublin, July 16.

"The Theorem of the Bride."

REFERRING to the last paragraph of the review of my "Greek Geometry from Thales to Euclid" which appeared in NATURE of June 20 (p. 172) it may interest some of your readers to know that since the publication of my book I have found the expression—τὸ τῆς νύμφης θεώρημα—in the Scholia on the "Elements of Euclid." See "Euclidis Elementa," ed. Heiberg, vol. v. p. 217, Lipsiæ, 1888.

The expression seems to have been a common name of Euclid i. 47. GEORGE J. ALLMAN.

Belsito, Milford, Lymington, July 18.

RECENT RESEARCHES INTO THE ORIGIN AND AGE OF THE HIGHLANDS OF SCOTLAND AND THE WEST OF IRELAND.[1]

I.

THE records of geological history, like those of the human race, become more fragmentary and illegible, the farther back we trace them into the past. While the younger rocks of the earth's crust have been made to yield a more or less connected story of geographical and biological evolution, the oldest rocks have till comparatively lately been neglected, or have been tacitly left to mere speculation and conjecture. Only within the last few years have these ancient formations been seriously and sedulously attacked by scientific methods of inquiry. Though the progress of investigation has necessarily been slow, a steady advance in knowledge can be chronicled. There is a curious fascination in this department of geology. These venerable rocks reveal to us the oldest known part of the outer shell of our planet. The palimpsest of the earth's surface has been written over again and again during the long ages of geological history; but down among these bottom-rocks we reach the earliest recognizable inscriptions, and come as near towards the beginning of things as geological evidence by itself is ever likely to lead us. These records carry us back to a time anterior to that of the oldest fossiliferous formations, possibly to an epoch that preceded the appearance of vegetable or animal life on the globe. They reveal to us the very foundations of the earth's crust, on which all other known rocks rest, and out of the waste of which the greater part of these rocks has been formed.

Within the last ten years, after prolonged misconception and neglect, the most ancient rocks of the British Isles have come to occupy a foremost place among the researches of the geologists of this country. The tracts where they are now exposed to view, often among the wildest mountains, or "placed far amid the melancholy main," have become favourite geological hunting-grounds, and have furnished a notable amount of material for those disputes and combats which seem to form a necessary element in geological progress. Avoiding, as far as possible, matters of controversy, I propose this evening to offer a brief outline of the actual state of knowledge, up to the present time, of the history of those ancient crystalline masses of which our north-western mountains are composed.[1] The story is a somewhat involved and complicated one. But its main points may perhaps be conveniently grasped, if we bear in mind that they naturally group themselves into four sections: (1) the Archæan period; (2) the Cambrian period; (3) the Lower Silurian period; (4) the period of the younger Schists.

Let me at the outset remark that in the investigation of these early ages of geological history we enjoy in this country a special advantage. The British Isles stand on the oceanic border of a great continental region. They are therefore placed along that critical belt where not only have terrestrial disturbances been especially numerous and violent from the earliest geological times, but where an oscillation upward or downward of a few hundred feet has sufficed to make all the difference between land and sea. In the heart of a continent, as, for example, over the vast plains of Russia, long cycles of geological time have passed without serious disturbance of any kind. To this day some of the ancient Palæozoic sediments in that region, for hundreds of square miles in extent, lie as level as when they were deposited on the sea-floor. They have been uplifted bodily into land, but still remain little more than mere hardened mud and sand. In Western Europe, on the other hand, where from the remotest geological antiquity the oscillations and dislocations have been innumerable, every successive continental uplift has recorded itself in some crumbling or fracture of the rocks. Hence in the geological map of that region the various formations form a pattern of exceeding complexity, while in the maps of Eastern Europe each of them covers a broad unbroken expanse.

I.—*The Archæan Period.*

The oldest known rocks of Europe, now generally termed Archæan, are well exposed along the north-western borders of the continental area from the extreme north of Scandinavia, by the west coast of Scotland, to Galway Bay in the west of Ireland, a total distance of some 1600 miles. They give rise to topographical features which, where fully developed, strongly distinguish them from all younger formations. Nowhere else can such extraordinary unevenness of surface be found. Knobs, hummocks, and ridges of bare or almost bare rock, separated by narrow gullies or by wider winding valleys, roughen the ground in every direction. In the hollows lie innumerable tarns and lakes, or flat tracts of bog where lakes once were. In some districts, indeed, there is as much water as land in a given number of square miles. On a large scale, this type of scenery is perhaps

[1] The Friday evening lecture delivered at the Royal Institution on June 7, by Dr. Archibald Geikie, F.R.S.

[1] It would be obviously out of place to include here references to the voluminous literature of the subject. A condensed summary will be found in the Report by the officers of the Geological Survey, Quart. Journ. Geol. Soc., vol. xliv., 1888.

best displayed in Finland; on a small scale, it is repeated all through the chain of the outer Hebrides, as well as on the Archæan areas of the mainland. The most southerly points in Scotland where it can be recognized are the Island of Iona and the Ross of Mull. It reappears, however, far to the south in Ireland; standing out in the bold cliffs from Erris Head to Achill Island in the west of Mayo, and finally covering an area of more than 500 square miles in South-Western Galway. In this last-named district, as Prof. Hull has shown, so completely are the scenic features of the north-west of Scotland reproduced, down even to the minutest details, that the geologist, even before he stands on the rocks, has no difficulty in deciding that they can only be Archæan.

What, then, are these most ancient rocks of North-Western Europe, and what has been their history? Unfortunately, the answer to these questions cannot be succinctly and definitely given. Owing to the antiquity of the masses, and the prolonged series of geological revolutions which they have undergone, their original characters have been somewhat effaced. In those areas where they have been least altered, and where, therefore, they approach nearest to their primitive structure, they have been found by my colleagues of the Geological Survey to be crystalline rocks, such as gabbros, diorites, and other highly basic compounds. These occur in zones or bosses surrounded by and passing into rocks which have acquired the peculiarly banded structure characteristic of gneiss. That these various rocks were eruptive—that is, that they originally formed portions of igneous material that rose in a molten or plastic condition from below—can hardly be doubted. They remind us of the deep-seated portions of some of the eruptive bosses so abundantly intruded into the crust of the earth, and now so plentifully exposed at the surface after prolonged denudation. Like these, they show a rudely striped or banded arrangement suggestive of the planes of movement or flow-structure seen in consolidated igneous material. They have probably resulted from successive protrusions of eruptive rocks at some depth within the crust of the earth.

Nowhere, however, in the region to which I am referring, has any trace of superficial eruption yet been detected. There are no true volcanic ejections, nor any evidence that the rocks, though certainly of eruptive origin, were ever connected with the ordinary explosive operations of volcanic vents. Not only so, but after the most careful search from Sutherland to Galway not a vestige have we yet found of any unquestionable sedimentary material. There are no conglomerates, no sandstones, no shales; nor even any materials that might be supposed to represent these in a metamorphosed condition. Of the actual surface of the earth these Archæan rocks afford no recognizable trace. They obviously did not form the superficial layer themselves. They must have lain deep under a cover of other material, under which they acquired their crystalline structure, and by the subsequent removal of which they have been exposed to the light.

One of the most impressive features of our recent researches among these rocks is the evidence of the magnitude of the interval of time between their original protrusion and the formation of the next group of rocks overlying them. Of the many breaks in the geological record, none is more complete than this. We pass at one step from Archæan rocks, dating no doubt from an early stage in the consolidation of the crust of the planet, to the gravelly and sandy deposits of an inland sea, which already present all the familiar characters of the sedimentary accumulations of later geological time.

Some of the more prominent events in this protracted interval may be more or less clearly discerned; others can only be dimly conjectured. Arranging in chronological order the more important which have lately been recognized by the Geological Survey, I would direct your attention to four main episodes in the Archæan history of our North-Western Highlands.[1]

In the first place, the crust of the earth over that region was thrown into a series of low arches or folds, the axes of which ran in a general north-east and south-west direction. Its component rocks were crushed and sheared, so as to acquire the banded and crumpled structure of typical gneiss. Perhaps we may trace to these primæval terrestrial movements the first shaping of the European continent, which certainly has grown from north to south. At all events, it is interesting to note that the undulations into which the rocks were thrown took that north-easterly trend which is still so marked in the long belt of crystalline schists from the North Cape all the way to the west of Ireland.

In the second place, after these early disturbances, and probably long after them, a remarkable series of manifestations of plutonic energy occurred. The region extending from the north-west of Scotland to the west of Ireland was convulsed by the production of innumerable dislocations in the solid terrestrial crust, having a general west-north-west direction. Up these gaping rents, molten basic lava rose from some subterranean reservoir, and solidified in broad dykes of black basalt. Some of these dykes can be traced for ten or twelve miles, till they run out to sea at the one end and pass under younger overlying formations at the other. Yet again, at a somewhat later period, another series of fissures was opened slightly oblique to the direction of the first; and, in these, still more basic lava formed a second series of dykes trending nearly east and west. Nor was this all, for there followed a third period of convulsion, which gave birth to a series of huge dykes of granite.

Whether or not any of the eruptive material that filled these successive fissures ever rose to the surface and flowed out there, or gave rise to the explosive phenomena of true volcanic vents, cannot be certainly affirmed. But an interesting piece of evidence points to the probability that such a connection with the surface was really established. In some of the conglomerates of the next succeeding group (Cambrian or Torridon sandstones), there occur fragments of highly vesicular lavas, which show that at some time previous to the deposit of these coarse sediments, active volcanic vents existed somewhere in the region of the north-west of Scotland. As yet, however, no trace has been discovered of any of the lava streams which flowed out at the surface.

Although volcanic energy has long been quiescent over the British Isles, probably no area in Europe exhibits within so limited a space so long and varied a record of volcanic eruptions. There is, therefore, a peculiar interest about these traces of the ancient volcanoes which in Archæan time rose along the Atlantic border in the north-west of Scotland, for they stand at the very beginning of that long history. Moreover, so far as we can interpret their remains, they seem in a curious way to have anticipated the characteristics of the last great volcanic episode in Britain—that to which we owe the Tertiary basaltic plateaux of Antrim and the Inner Hebrides. In both cases the distinguishing feature was the fissuring of the terrestrial crust and the uprise of basic lava in the rents, with the consequent production of innumerable parallel dykes trending in a general north-westerly direction.

In the third place, after the production of the basic dykes, there came another prolonged interval, during which a series of remarkable terrestrial disturbances affected the north-west of Scotland. The crust of the earth in that part of Europe was once more dislocated by innumerable fissures, produced probably at successive epochs of paroxysm, for they can be grouped into three distinct series. Of these, one runs approximately parallel

[1] Those who wish fuller details on this subject will find them in the Survey Report already quoted.

with the north-west dykes, the second trends east and west, and the third runs north-east and south-west, or north and south. So far as yet discovered, no lava of any kind welled upwards into these fissures. They are ruptures, but not dykes. They were accompanied, however, by the manifestation of another form of terrestrial energy, the geological efficacy of which has only recently been recognized. The lines of vertical fracture became also lines of horizontal or oblique movement during the vast strain of terrestrial contraction. One side was driven past the other side, and with such irresistible force that the rocks for some distance on either side were dragged into the line of movement, crushed down, and forced to assume a new crystalline arrangement of their materials. The basalt dykes, reduced sometimes from a width of 50 or 60 yards to only 4 feet or less, were changed into diorites, and where the shearing was greatest, into hornblende-schists. The gneiss, in like manner, was thrown into sharp folds, and had a newer foliation developed in it parallel with the new planes of movement.

In the fourth place, during the prolonged succession of changes which I have thus briefly summarized, there must have been in progress a continuous denudation of the surface of the Archæan land in the north-west of Europe. Doubtless, each of the subterranean disturbances more or less affected the surface. The land was by degrees ridged up above the sea, and its height and breadth were probably from time to time increased by local uplifts accompanying the disturbances. But as soon as the land appeared, it began to be attacked by the waves, the air, rain, and running water. Terrestrial convulsions were intermittent, but superficial waste continued uninterrupted. Whatever may have been the character of its topography, the first formed land, as soon as it rose, became a prey to the denuding forces, and had its original surface gradually stripped off. We have no means of telling how great a thickness of material was in this manner removed from the land before the time of the next geological period, nor for how vast a time this slow process of denudation went on. All that we can now discover is a series of detached fragments of the surface of this primæval Europe, which have been preserved by being buried under the pile of material formed out of the waste of the Archæan rocks. From these fragments we learn that the rocks had been enormously denuded so as to lay bare to the surface some of their deep-seated parts, the land shaped out of them having been carved into dome-shaped hills and basin-like hollows, not very different from those which are so characteristic of the Archæan tracts to-day.

II.—*The Cambrian Period.*

We now reach the base of the stratified formations of the British Isles, and enter upon a series of records which deal not with subterranean but with superficial changes, and in which the earliest geographical conditions of our area are more or less fully chronicled. These records consist of a pile of dull-red sandstones, conglomerates, and breccias, with grey, green, and black mudstones, marls, and shales, attaining a maximum thickness of perhaps 10,000 feet. This great accumulation, chiefly of coarse sediment, was derived from the waste of the Archæan land. The pebbles in its conglomerates are fragments of that land, and enable us to form some conjecture as to the nature of the materials that composed its surface. An examination of these pebbles brings to light the important fact that besides the detritus of the gneiss and other Archæan rocks which can now be seen *in situ*, the conglomerates are made up of materials derived from some still older sedimentary formations which have entirely disappeared from our area. These included such rocks as quartzite, greywacke, shale, and limestone, besides abundant pieces from the lavas, which I have already referred to as having probably been erupted to the surface in pre-Cambrian time. The destruction of these intervening deposits, and the chance discovery that they once existed because fragments of them have been found in later conglomerates, serve to impress upon us the imperfection of the geological record, and the vastness of the intervals of time which may sometimes separate two successive groups of rock.

The thick mass of red sandstone and conglomerate which rests directly on the Archæan gneiss forms some of the most singular scenery in the north-west of Scotland. Owing to vast denudation, which began before the next group of strata was deposited, it has been worn down into isolated mountains, which rise like a chain of colossal pyramids along the western shores of Sutherland and Ross. The almost level lines of stratification give to these eminences a look of architectural symmetry, in striking contrast with the more tumultuous aspect of the other rocks of the region, while their red tone of colour marks them out boldly from the wastes of grey gneiss below and the crags of white quartzite beyond. From the far northern cliffs of Sutherland these massive red sandstones can be followed almost continuously to the southern headlands of Skye. They reappear in great force in the Island of Rum, beyond which they are not certainly traceable. A group of highly altered grits and schists, seen under the great basaltic plateau of Gribun, on the west side of the Island of Mull, may mark their extreme southerly limits.[1] The red sandstones certainly do not come so far south as Iona, and not a trace of them has been met with in Ireland. They extend westwards across the Minch, for a small portion of them skirts the eastern shore of the Long Island. How far they may have stretched eastward cannot now be determined, for their limits in that direction have been obscured or effaced by the extraordinary series of gigantic earth-movements to be afterwards referred to. There can be little doubt, however, that they did not reach the district east of the line of the Great Glen, though they not improbably lay in thick mass over much of the country to the west of that valley.

We cannot now trace the original limits of these red rocks, yet we can hardly doubt that they never covered an area at all comparable in extent to that of the rocks below and above them. They appear, indeed, to have been accumulated in one or more basins, shut off from free communication with the open sea, where the deposition of ferruginous precipitates among the ordinary mechanical sediment could go on during the deposition of many thousand feet of rock. Such conditions of sedimentation were not very favourable to the existence of life in the waters of these inclosed basins. Nevertheless, that the waters were not entirely lifeless is shown by the discovery of organic remains on two widely separated horizons among the sandstones. These remains occur in grey and dark shales, the colour and composition of which suggest a temporary influx of water from without, and the cessation for a time of the deposition of the iron-oxide. At the lower horizon the fossils consist of calcareous rods, the organic grade of which is still in dispute; at the higher they include some doubtful impressions and the casts of worms. The fossiliferous bands are to be more thoroughly searched this summer, and it is hoped that something more determinable may be obtained from them.

Nevertheless, indistinct though these relics undoubtedly are, they may claim the interest which arises from their being at present the very oldest traces of organized existence yet found within our islands. Murchison classed the red sandstones of Western Sutherland and Ross as "Cambrian," inasmuch as he found them to

[1] My attention was called to these rocks by the Duke of Argyll, who himself suggested their possible Cambrian age. I visited them this spring, and found them to be greatly metamorphosed. They do not appear in Iona, where the base of the sedimentary series is found resting on the Archæan gneiss.

underlie unconformably strata containing what he believed to be Lower Silurian fossils. It is not improbable, however, that they belong to an older time than any of the Cambrian rocks of Wales.

That the red sandstones of the north-west of Scotland were laid down in shallow water seems to be clearly indicated by their current-bedding and ripple-marks, as well as by the occurrence of bands of conglomerate among them on many successive horizons. Yet they retain these characters throughout a depth of some 10,000 feet. We can walk over their edges and count every successive stratum for a thickness of more than 3000 feet along the sides of a single mountain. How, then, could such a continuous mass of shallow-water deposits be accumulated? I am not sure that any wholly satisfactory answer can be given to this question, which is one that arises in the investigation of various epochs of geological history. That the basins must have been due to local subsidence can hardly be doubted. We may suppose that this downward movement continued at the same time that the ridges which bounded the hollows continued to be forced upward. New shore-lines would thus be brought to the level of the water, and coarse shingle might be swept down upon previously deposited fine sediment. If occasionally the barrier between the basins and the open sea were partially submerged, the muddy ferruginous water of the inclosed tracts might be cleared out, and the denizens of the sea might for a time enter them. Possibly the grey and dark shales may mark these irruptions of the ocean.

That similar conditions of geography prevailed at that period in the extreme north-west of Europe is indicated by the fact that in Norway a group of red sandstones and conglomerates, known as the "sparagmite rocks," is interposed between the Archæan gneiss and the oldest of the fossiliferous formations. In these Scandinavian rocks we probably see traces of the extension of similar inclosed water-basins along the eastern border of the primæval Atlantic Ocean northwards among the hollows of the Archæan land.

Before the next great geological period these basins had been entirely effaced, and the geography of the region had wholly changed. This transformation is probably traceable to two causes. First, the terrestrial movements which led to the formation and continuance of the basins may in the end have caused their extinction by raising them into land, and possibly at the same time by folding and fissuring their accumulated deposits. Secondly, as soon as these deposits, whether split open or not, were exposed to the atmosphere they would begin to be worn down. That erosion took place during a prolonged period, and to a vast extent, is shown by the fact that in some places the thick cake of sandstone was hollowed out down to the Archæan platform below it before the next succeeding formations were deposited. Here again we are presented with a striking example of the imperfection of the geological record.

(*To be continued.*)

THE PRIVATE LABORATORY OF MARINE ZOOLOGY AT RAPALLO.

THIS very modest zoological station does not in the least pretend to compete with the splendid ones of Naples, Plymouth, Roscoff, Banyuls, &c. Considerable sums are needed to build and keep up such establishments, so that their numbers will necessarily be always very limited.

We have thought that with relatively little expense it might be possible for zoologists to procure in great part the advantages that these larger stations offer, and to concur in their action, by establishing a certain number of small stations on favourable spots of the Italian coast. Our idea is to have dependencies of the zoological laboratories of the nearest Universities, almost as if parts of those laboratories were transported to the sea-shore. The cost of these stations would not be very great. All that is strictly necessary is a room with good light, and as near as possible to the sea, provided with small aquariums, with the usual pump, with fishing apparatus, and the ordinary furniture of every laboratory, except microscopes and other costly instruments, which every investigator would bring with him. The books also might be reduced to the treatises and the "Faunæ" ordinarily used. It is indispensable that the station should possess at least one boat for short excursions: for deep dredging, and for longer excursions that are less often made, the necessary vessels could be hired.

By these modest means notable results might be obtained. Almost all anatomical and histological researches would be possible, the inquirer either making them entirely on the spot, or limiting his work to the first observations that ought to be made on specimens freshly caught, and preparing the materials for later and more leisurely study.

Stations of this sort already exist abroad, such as the laboratory of marine zoology of Wimereux, the Netherlands movable station, the station of Misaki in Japan, &c.

In Italy, Prof. Kleinenberg proposed to found a station of this kind at Messina, but of greater proportions, hoping that it might serve principally as a school for beginners; but unfortunately his idea has not yet been realized. Neither has anything come of the project of Count Alessandro Ninni to establish a station at Venice that might serve at the same time for purely scientific researches, and for practical studies on the industrial cultivation of sea animals.

Convinced of the utility of small stations, we have made an experiment in forming one which we will now describe.

Unwilling to go too far from Turin, we have chosen the little town of Rapallo on the Eastern Riviera, near Genoa. It is situated at the end of the gulf of the same name, is one hour's distance by boat from Portofino, that marks the extremity of the gulf towards Genoa. The Gulf of Rapallo is pretty well sheltered from the winds; the shores are rather rocky, and vegetable and animal life is very various and abundant. It also presents notable variations of depth. From Rapallo to the extremity of the gulf, a distance of 4 kilometres, the depth gradually reaches 90 metres, and at a like distance in the open sea of Portofino, the depth is more than 400 metres. The movement in the haven is limited, and hence the waters even near the town are clear. As to the town, it is beautifully situated, and the neighbouring places are various and very pleasant. It is also a very quiet town, where the greatest liberty can be enjoyed.

Our station occupies a space of a hundred square metres, and it is placed a few metres from the sea, on the ground where the docks formerly stood. In this space, inclosed by a wooden palisade, is the little building which looks like a *chalet*, the lower part in brick-work, with wooden walls and a roof covered with zinc. The edifice consists of only one large room, 7 metres in length, and 4·50 in width (inside). The height up to the wooden ceiling, that is under the roof, is about 4 metres. One of the longer walls is turned to the north. A window, consisting of nine large divisions, runs the whole length of this wall; and against this wall is placed the working-table, which also occupies the whole length; at it six persons can work. The door is on the shorter side that looks on the sea; over the door is placed the reservoir of sea-water capable of containing more than 800 litres; it is filled by a small rotatory pump. By means of pipes the water is brought from this reservoir into the aquariums that are placed in the middle of the room on an iron support of two stories, provided with the necessary discharge-pipes to carry off the water that has circulated in the aquariums. Against the shortest wall, opposite that in which the door is placed, there is a table covered with porcelain for chemical manipulations. Above this table there is a reservoir of fresh water. In the middle of the room, behind the support of the aquariums, are two tables covered with marble. Against the wall opposite the window are the shelves for the instruments and for the collections. One corner is set apart for the principal fishing implements.

The station has a boat, the *Bonellia*, that serves for short excursions, and for researches in shallow water. The fishing implements consist principally of trawl-nets for the depth, nets for surface fishing, apparatus for extracting masses from the bottom, sieves, nets, harpoons, &c. These implements have been made expressly at Naples, under the supervision of Dr. Paolo Mayer, of the Zoological Station.

The station is also provided with numerous aquariums for study, and with the necessary chemical apparatus. The library is limited to the more common and useful treatises, and to a certain number of memoirs concerning the marine fauna.

We hope that even by these simple means it will be possible to obtain satisfactory results. Many important works on marine zoology have been produced far away from zoological stations under less favourable conditions than those of our little station.

L. CAMERANO.
M. G. PERACCA.
Zoological Museum, Turin. D. ROSA.

WEISMANN ON THE INHERITANCE OF INJURIES.[1]

IN an address to the Naturforscher-Versammlung at Cologne, last autumn (now published in a compact pamphlet of fifty-two pages), Dr. Weismann examined the evidence for the inheritance of injuries. In earlier works he has shown that the facts of organic evolution can be explained without the hypothesis of the inheritance of acquired characters, and his theory of the germ-plasma as the basis of heredity is hardly compatible with the traditional and Lamarckian view. The supporters of the old view have laid great stress upon the transmission of the effects of injuries. A great many of the cases relied on rest on merely anecdotal evidence, and Weismann examines and dismisses many types of them. Such, for instance, is the case adduced by Dr. Zacharias, and quoted by Eimer, of a tailless cat which produced tailless kittens. Nothing whatever of how the mother lost her tail is known, and nothing is known of the father. Tailless kittens appearing suddenly in villages have been traced, more than once, to an imported male of one of the many tailless breeds. In any particular case, it is as logical to refer the appearance of tailless kittens to a hypothetical mutilation of the mother, as it would be to deduce from the many-toed Oxford cats that Mr. Poulton had fixed additional toes on the paws of their ancestor!

Weismann made an elaborate series of experiments on mutilation. On October 17, 1887, he had the tails removed from seven female and five male white mice. On November 16 the first brood appeared. These, and all subsequent broods, were removed from the cage. Up to December 17, 1888, 333 young were born, and in none of them was there any sign of the mutilation being inherited. In cage 2, fifteen young, of December 2, 1887, were placed, their tails having been removed. These, up to December 17, 1888, produced 233 young, all with normal tails. In cage 3, fourteen young of the second generation, with tails removed, were placed; and up to December 17, 1888, they produced 141 young, all quite normal. The experiment was carried, with a negative result, down through five generations of mutilated animals. The length of tail of new-born mice varies from 10·5 millimetres to 12 millimetres. In the series of experiments, 849 young were produced by mutilated progenitors, and in no case was a mouse produced with its tail less than 10·5 millimetres.

The author points out that, while it might be said that experiments through a far greater number of generations were needed, the so-called cases of inheritance of mutilation all imply that the mutilation is impressed on the immediately following generations. A mother breaks her finger, and her daughter has the joint of the corresponding finger imperfect. A cow has her horn torn off, and, in due course, gives birth to a one-horned calf.

Moreover, there are many cases of mutilations which have been made for hundreds of years without result. For instance, Settegast shows that all the crows but the rook have bristly feathers on their beaks. Rooks, too, have these feathers while nestlings; but, later on, they lose them by perpetually pushing the beak into the ground in search of food.

There are a great many cases which at first sight appear to prove the inheritance of injuries. As an example of how easy it is to be deceived, Weismann relates that a friend had a vertical scar (with comb-like striæ) on the left ear, the result of a sword-wound. On the left ear of this gentleman's daughter was a curiously similar marking. But it was ultimately noticed that on the right ear of the father was an appearance precisely similar to that on the left ear of the daughter. On closer examination of the father's left ear there was seen, under the scar, a linear streak, from which the striæ ran, forming a comb-like structure. It was this, doubtless a congenital variation, and not the accidental scar, that the daughter had inherited.

It is impossible to give, by extracts, an adequate conception of Dr. Weismann's ingenious analysis and masterly collation of evidence. There is enough in it to satisfy the most conservative of biologists (at least without a theory) that the transmission of injuries must be handed for ever to the "scientific novelist" and the jaded melodramatist. With them it may flourish, and rescue many a doubtful heir, and secure the happiness of many a heroine in the third volume, or before the curtain falls.

It is not so certain that all will admit Weismann's contention that the demolition of the inheritance of injuries furnishes strong presumptive evidence that acquired characters are not inherited. It might well be urged that there is a great distinction between characters which are obviously not useful (such as injuries) and useful characters. It is clear that if acquired characters are inherited it would be of the highest utility if the inheritance were selective. The tiny piece of ancestral germ-plasma increases exceedingly during the ontogeny. Has the distinction between germ-plasma and somatic plasma passed sufficiently out of the region of theory to let us infer, from the non-reflection of injuries during the process of growth, that all acquired characters are not reflected? Can we hold that, were acquired characters reflected, injuries too must be reflected? It is a question, on the one hand, of the nice adjustment of fine probabilities; on the other, of elaborate, long-continued, and specially directed observation. But, whatever is the final answer of science, this essay will be not the least of the author's many valuable contributions to it.

P. C. M.

[1] "Ueber die Hypothese einer Vererbung von Verletzungen." Von Dr. August Weismann, Professor in Freiburg i. Br. (Jena: Gustav Fischer, 1889.)

COAL AND TIN DISCOVERIES IN WESTERN AUSTRALIA.

MR. HARRY P. WOODWARD, Government Geologist for Western Australia, sends, under date May 28, 1889, some interesting particulars of both coal and tin discoveries in that colony. He writes:—

"From Vasse I made for the Lower Blackwood River Bridge, over the foot of the Darling Range, and so on to the Donelly River. On the south coast, where a small stream flows out, called the Fly Brook, coal has been found of a very good quality, but there is no port nearer than Albany or Vasse, and this latter is not a good one. There seems to be a line of coal-bearing country between the coast-range, which runs north and south from Cape Leeuwin to Cape Naturalist, and the main highlands, the southern continuation of the Darling Range; much of it covered with sand and swamps at the surface, but under which I believe we shall find coal-measures which may, in fact, extend west beneath Perth to the Irwin River, but this can only be tested by deep borings.

"There was nothing to be seen of the coal or rocks, as they are boring with a 'jumping-drill,' which reduces everything to mud, but there is one 5-foot seam and several smaller, averaging 17 feet of coal in 200 feet of rock. There are two or three outcrops in the bed of the Creek of a much weathered but good coal, some of which is highly bituminous. From Bridgetown I went to Albany, and thence east 200 miles to the Phillip River, and saw the Fitzgerald Coal-field. This is only brown coal or lignite of no value, but there is some good-looking gold-bearing country near it."

TIN-ORE.—In reference to the tin discoveries, Mr. H. P. Woodward writes:—

"From Bunbury I went towards the Upper Blackwood, to a place called Bridgetown, where tin has been found. Little work has been done yet, but, as far as I am able to judge, it seems to indicate the biggest thing of the kind that has ever been found. One shaft, 18 feet deep, will wash all the way down at about 4 or 5 pounds to the pan, and they have not got to the bottom of it yet. The richest works in other colonies are rarely more than 2 or 3 feet deep. Tin has been found at the surface, in the sand, over an area of about 100 square miles, but no sinking, except the one shaft, has yet been made; and as the surface is covered, either with sand or clay-ironstone, the formation cannot be seen at all. The late Mr. Edward T. Hardman suggested that tin would be found here. The shaft shows a few inches of soil or alluvium with gravel containing tin, where it was first found, resting on hard masses of clayey ferruginous sandstone, about 1 foot thick, then coarse quartz-grit with stream-tin and tourmalines and a few 'colours' of gold. 17 feet not gone through yet, as there was too much water, about $\frac{1}{6}$ in weight being tin-ore." H. W.

NOTES.

THE Committee appointed to consider the basis upon which the grant of £15,000 a year for University Colleges in Britain should be distributed have recommended that the grant should be divided as follows:—To Owens College, Manchester, £1800; to University College and King's College, London, £1700 each; to Liverpool University College, £1500; to Mason College, Birmingham, the Yorkshire College, Leeds, and Nottingham University College, £1400 each; to Bristol University College, the Durham College of Science, Newcastle-on-Tyne, and Firth College, Sheffield, £1200 each. The Committee are of opinion that University College, Dundee, should be dealt with in connection with the Scottish Universities, and especially with the University of St. Andrews; but they recommend that it should for the present year have a grant of £500.

A TESTIMONIAL is to be presented to Prof. Kennedy by his former students on the occasion of his resignation of the Chair of Mechanical Engineering at University College, London. A committee has been appointed to receive subscriptions, and no doubt many persons will be glad to have this opportunity of expressing gratitude for the profit they have derived from Prof. Kennedy's instructions. The Chair from which he is retiring he has held during the last fifteen years.

IN answer to a question put by Mr. Acland in the House of Commons on Monday, Mr. W. H. Smith said the Government were aware of the great interest taken by the country in technical education, and the pressing importance of dealing with it. They had been engaged during the previous few days in endeavouring to find some solution of the difficulty which surrounds the question in regard to elementary schools, but, he regretted to say, without success. The Government therefore proposed to introduce at once a measure dealing with the higher branch of the subject.

AT a general meeting of Welsh members, held at the House of Commons on Tuesday, for the purpose of conferring with Sir W. Hart-Dyke on the Intermediate Education (Wales) Bill, the Vice-President of the Council announced that, provided all the amendments on the paper were withdrawn, the Government were willing to accept an arrangement whereby the Education Council to be constituted under the Bill should consist of five members—three to be nominated by the County Councils, and two by the Education Department. Were the meeting to agree to this, then the Government would use their best efforts to pass the measure into law before the end of the session. The proposal thus made was debated at some length, and was finally adopted.

THE half-yearly general meeting of the Scottish Meteorological Society was held yesterday in Edinburgh. The Council of the Society presented its report, and the following papers were read:—"Proposed Investigation of the Numbers of Dust Particles in the Air at the Ben Nevis Observatory," by Prof. Tait; "The Distribution of Temperature over the Globe," by Dr. Buchan.

AT the last meeting, this session, of the Royal Society of Edinburgh, the Chairman, Prof. Chrystal, in closing the business, said that, during the period, 86 papers had been read, of which 21 had been in the department of natural philosophy, 16 in mathematics, 7 in chemistry, 2 in geology, 6 in zoology, 6 in botany, 23 in physiology, 2 in astronomy, and 3 in meteorology. A good number of these papers had come from the newly-instituted laboratory in the College of Physicians, and he congratulated that body on the public spirit manifested in the opening of the laboratory, and on the excellent results that followed. Eighteen new members had been added to the roll, the average in the three previous years having been 36; and 7 ordinary and 2 honorary members had been lost by death.

THE floral *fête* of the Royal Botanic Society, held on the 15th inst., to celebrate the jubilee, is a fitting occasion to recall the memory of the founder, Mr. Philip Barnes, who originated the idea, and planned and carried into execution the installation of the Society. The faculty of creation is not given to everyone. Due honour should therefore be given to those who, endowed with it, use it for the interest of science and the public good.

AT the Congress of Physiological Psychology, to be held in Paris (August 5–10) the following subjects will be discussed: muscular sense; *rôle* of movements in formation of images; is the attention always determined by affecting states?; statistical study of hallucinations; the appetites in idiots and imbeciles; are there in insane persons motor impulsions independent o images and ideas?; psychical poisons; heredity; heredity of emotional phenomena and their expression; heredity of peculiarities in the perception of colours; heredity of special memories and of special aptitudes (technical, artistic, scientific); psychological analysis of some genealogical tables; hypnotism; causes of errors in observation of phenomena of hypnotic suggestion; normal and hypnotic sleep; motor power of images in hypnotized subjects, and unconscious movements (automatic writing, &c.); doubling of personality in hypnotism and mental alienation; phenomena of transfer; precise terminology in questions of hypnotism. (Communications to M. Richet, 15 Rue de l'Université, Paris.)

THE Leaf-insect of the Seychelles lately living in the Zoological Society's Insect House, which we figured in our issue of May 30 (p. 105), has unfortunately died, before attaining complete development. But specimens of two other scarce Orthopterous insects have lately been added to the collection. Many examples of one of the curious Stick-insect (*Diaphemora femorata*) of North America have lately been hatched from eggs received from Mr. Williams, of Toronto. The young insects are feeding well on the leaves of the common hazel and grass, and some of them have already attained a considerable size, while others are still emerging from the ova. Besides these, two examples of a very singularly shaped form of Mantidæ from South Africa (*Harpax ocellata*) have just been received from Colonel J. H. Bowker, of Durban, and appear likely to do well. A third object of considerable interest, lately lodged in the Insect House, is a fine example of the Cocoa-nut Crab of the East Indies (*Birgus latro*), presented by Commander Alfred Carpenter, R.N. This is a terrestrial Crustacean of peculiar structure, which subsists entirely upon vegetable food, and is said to be able to open cocoa-nuts. Darwin has given an interesting account of its habits in his "Naturalist's Voyage," and Prof. Moseley met with it in one of the Philippine Islands during the voyage of the *Challenger*. The Zoological Society's example appears to prefer bananas to other food, but has also eaten some lettuce.

M. DESCHAMPS, a French zoologist, has, says the *Ceylon Observer*, arrived at Colombo from Singapore. He has been sent out by the French Government to study the zoological features of the Laccadive Islands, but as it is almost impossible to reach them during the south-west monsoon, he will spend two or three months in Ceylon, during which time he hopes to pursue his researches in various parts of the island. About October he will make his way to the Malabar Coast, and from thence to the Laccadive Islands.

THE Government Geologist of New South Wales has prepared a map showing the areas within which artesian water-supplies may be bored for with good prospects of success. Water-bearing formations extend for 60,000 square miles in the arid parts of the colony, where permanent supplies are most needed; and the system of artesian wells is being widely adopted throughout Australia with the most satisfactory results. Large tracts of good pastoral country, which have hitherto been totally valueless through the want of a regular water-supply all the year round, are now capable of supporting flocks and herds.

THE Audubon Monument Committee of the New York Academy of Sciences complain that as yet comparatively few members of the Academy have given anything towards the erection of the proposed monument to Audubon. The considerable sum already received has come mainly from others. The plans accepted by the Committee will require from $6000 to $10,000 for their execution. Up to the present time, about $900 has been received. The Committee have issued a portrait of Audubon, suitable for framing, a copy of which will be sent to everyone who contributes to the fund to the amount of a dollar or more.

ACCORDING to an official notification of the trustees of the "Schwestern Fröhlich Stiftung" at Vienna, certain donations and pensions will be granted from the funds of this charity this year in accordance with the will of the testatrix, Miss Anna Fröhlich, to persons distinguished in any branch of science, art, or literature who may be in want of pecuniary support through accident, illness, or infirmity consequent upon old age. The grant of such temporary or permanent assistance in the form of donations or pensions is, according to the terms of the foundation deed, primarily intended for Austrian artists, literary men, and men of science, but foreigners of every nationality may benefit by the fund provided they are resident in Austria. Austrian subjects residing in England, who may desire to make application for a grant, can obtain all necessary information at the Austro-Hungarian Embassy in London.

ACCORDING to a telegram from New York, dated July 20, there had been slight shocks of earthquake at Memphis and in the vicinity.

THE Pilot Chart of the North Atlantic Ocean for July shows that two well-defined depressions moved up along the American coast during June. One originated over the Bahamas, on the 1st, whence it moved about north-north-east, accompanied by moderate gales, and disappeared in New England on the 5th. The other was a typical West India hurricane in every respect except violence; it first appeared south-west of Jamaica on the 14th. Heavy rainfall accompanied the passage of the storm, and caused great damage in Cuba, and on the 20th the depression seems to have united in Canada with another from the Lake region, and the combined storm moved east-north-east over Labrador, and out to sea. Much fog was encountered during the month, and many icebergs were reported between the 40th and 50th meridians, and as far south as 42° 54′ N., showing a marked southerly drift. The fact that the fog-belt is apt to overlap the iceberg region at this season makes navigation dangerous over the Transatlantic lines. One of the wrecks has an interesting history. The Italian barque *Vincenzo Perrotta*, abandoned on September 18, 1887, began her remarkable drift in about lat. 36° N., long. 54° W., and when last reported, on April 4, 1889, was about sixty miles north of Watling's Island, in the Bahamas, having made a distance of about 1400 miles in a south-west by west direction in little more than a year and a half.

AT the meeting of the Linnean Society of New South Wales, on May 29, Mr. C. T. Musson exhibited the leg of a pigeon to which a ball of earth, weighing, when dry, 9 grains, was found adhering. It would be hard to find a more striking illustration of the way in which birds may be the means of dispersing seeds. Mr. Musson also recorded a case in which a land snail (*Vitrina* sp.) was found adhering to the elytron of a beetle, whereby its migration beyond its normal habitat was to a limited extent rendered possible.

IN an article on "Blindness and the Blind," in the current number of the Journal of the Franklin Institute, Dr. Webster Fox refers, among other things, to the need for care being exercised with regard to the eyes of young children. The eyes are more sensitive to light in childhood than in adult life, yet a mother or nurse will often expose the eyes of an infant to the glare of the sun for hours at a time. Dr. Webster Fox holds that serious evils may spring from this, and he even contends that "the greater number of the blind lose their sight from carelessness during infancy." From the point of view of an oculist, he protests against the notion that children should begin to study at a very early age. He thinks that until they are between seven and nine years old the eye is not strong enough for school work. When they do begin to learn lessons, they "should have good light during their study hours, and should not be allowed to study much by artificial light before the age of ten. Books printed in small type should never be allowed in school-rooms, much less be read by insufficient light."

IN the new volume of the Transactions and Proceedings of the New Zealand Institute there is an instructive paper by Mr. A. Reischek on the wandering albatross (*Diomedea exulans*). Towards the end of January 1888, he had an opportunity of watching this bird closely among the hills of one of the Auckland Islands. Starting in search of some specimens, he was lucky enough, after a good deal of climbing, to come to a slope where a colony of albatrosses had established a breeding-place. The birds were scattered about among the tussock-grass, sitting on their nests, and from their white plumage could be easily distinguished from the vegetation at a great distance. Mr. Reischek found that their nests are always placed on sloping ground, and always on the most exposed side of the hill. The nests are composed of earth and grass cemented together, and are built in the form of a cone. They are usually about 2 feet in diameter and about 18 inches high. Outside they are surrounded by a shallow drain, intended to carry off the surface-water. Within is placed a single egg. This is white, with a few brown spots on the broad end, and measures about 5·5 inches in length by 3·1 inches broad. In most cases he found the female on the nest, the male bird standing close to her, and occasionally feeding her. Sometimes the male relieved the female, but they never both leave the nest until the young one is able to defend itself against the skua gull, a rapacious bird which devours every egg or nestling left unprotected. When Mr. Reischek approached an albatross's nest, the bird seldom left it, but set up a croaking noise, clapping its mandibles together and biting at the intruder. If it was turned off, and the egg taken, it returned and sat on the nest as before. The eggs were quite fresh on January 25, and good for eating when fried.

A VOCABULARY of physical terms, styled "Butsurigaku Jutsugo Jisho," has been issued in Japan. It gives the authoritative Japanese equivalents of an important group of Western scientific terms. In all, thirty-six Japanese gentlemen have been engaged in its preparation for the past six years. The Mathematical and Physical Society of Japan bears the expense of publication. The book consists of four parts arranged alphabetically under the four languages, Japanese, English, French, and German, each part extending over ninety octavo pages, and each page comprising from twenty to twenty-five distinct terms expressed in the four languages. This work, on which so much labour has been expended, can be purchased for the moderate sum of a dollar and a half.

MESSRS. MACMILLAN AND CO. have issued a "Syllabus of Modern Plane Geometry," by the A.I.G.T. The first few sections deal with harmonic ranges and pencils, the properties of the triangle, and properties of the complete quadrilateral and quadrangle; sections v., vi., and vii., with the properties of circles and geometrical maxima and minima; sections viii. and ix., with cross ratios, involution, and reciprocal polars and projection. The various subjects are treated concisely, and the work will be very useful to students.

"HAMPSTEAD HILL," a work on the natural history, &c., of Hampstead, will shortly be published by Messrs. Roper and Drowley. The contributors to the various sections include Prof. J. L. Lobley, H. T. Wharton, Rev. Dr. Walker, and J. E. Harting. The book will be illustrated by engravings of local scenery.

THE second part of Charles Fabre's treatise on photography has just been published (Gauthier-Villars, Paris). The subject of lenses is continued in great detail, and it is not too much to say that a more complete account has never been written. Diaphragms and instantaneous shutters are begun in this part. The illustrations are excellent.

THE Royal Physical Society of Edinburgh has issued its Proceedings during the session 1887-88. The volume includes, besides an opening address, by Prof. Duns, Vice-President, the following papers:—An ornithological visit to the Ascrib Islands, Loch Snizort, Skye, by John Swinburne; on the structure of the Graafian Follicle in *Didelphys*, by Frank E. Beddard; notes on Carboniferous *Selachii*, by Dr. R. H. Traquair, F.R.S.; further notes on Carboniferous *Selachii*, by Dr. R. H. Traquair, F.R.S.; notes on a visit to Fernando Noronha (with plate), by George Ramage; on a new Eurypterid from the Upper Coal-measures of Radstock, Somersetshire (with plate), by B. N. Peach; synthetic summary of the influence of the environment upon the organism, by J. Arthur Thomson; on the prevalence of Eurypterid remains in the Carboniferous shales of Scotland, by James Bennie; on the fructification of two Coal-measure ferns (with plate), by Robert Kidston; on the fructification and affinities of *Archæopteris hibernica*, Forbes, sp., by Robert Kidston; notes on the equipment of the Research Laboratory of the Royal College of Physicians, Edinburgh, by Dr. G. Sims Woodhead; the summer birds of Shetland, with notes on their distribution, nesting, and numbers, by Harold Raeburn.

THE July number of the *Board of Trade Journal* describes, from certain Austrian technical periodicals, the condition of pharmacy in Bulgaria. Most of the departmental capitals, towns of 9000 to 10,000 inhabitants, but including very often an administrative area of 60,000 to 70,000 inhabitants, have only one pharmacy each. These pharmacies might be supposed to do a splendid trade, and they would do so but for the fact that the illegal exercise of the craft, in spite of the stringency of the laws which are intended to protect the legitimate professors of the art, is almost openly practised throughout the country by itinerant hawkers, quacks, and priests. The establishment of pharmacies is only allowed by special concession, and they are subject to a Sanitary Council at Sophia composed of several members, including a chemist and a veterinary surgeon. Nominally there should be a pharmacy for every 8000 inhabitants. Every Bulgarian citizen who has passed the necessary examination is entitled to compete for a concession, but foreigners are only allowed to do so when they can show that they have been qualified in their own country, and after having passed a formal examination in Bulgaria. At least twice a year every pharmacy is officially inspected by the authorities, and subjected to a close examination, which also extends to the books, as there is an official scale of charges for prescriptions which may not be exceeded. The original of every prescription is kept by the pharmacist, who gives his customer a copy stamped with his name, and bearing the price charged, which price is also inscribed upon the original, and the same number given to both. At present the Russian Pharmacopœia is used in Bulgaria, but a native one is in contemplation. There is no Pharmaceutical Society or organization of any kind among pharmacists. A Society which was started about five years ago expired after an existence of three months. The formal examination which is obligatory for foreigners desirous of establishing business in Bulgaria embraces pharmacology, analysis, organic and inorganic chemistry. The fee is very high, £40, half of which is refunded in case of failure. Every foreigner establishing business in Bulgaria is required to sign a declaration placing him under the Bulgarian Pharmacy Law, and to keep at least two apprentices of Bulgarian nationality. The assistants are nearly all foreigners. They generally receive from £2 10s. to £3 per month indoors.

THE barium salt of a new acid-forming oxide of cobalt, CoO_2, corresponding to the black dioxide of manganese, MnO_2, has been obtained by M. Rousseau, and is described in the current number of the *Comptes rendus*. It forms large black prismatic crystals, and appears to be a very definite compound of the composition $BaO . CoO_2$, and possessing some stability. The most favourable method of preparing it is as follows. A mixture of 15 grams of crystals of barium chloride or bromide with 5 or 6 grams of finely-powdered anhydrous barium oxide is heated gradually to redness in a platinum crucible. The temperature is then raised in a good furnace to 1000°–1100° C., when 1 gram of sesquioxide of cobalt, Co_2O_3, is introduced by degrees into the fused mass, and the temperature maintained for about five hours. At the expiration of this time a ring of large black prisms, exhibiting beautiful iris-coloured reflections, is formed. The crystals are found to contain a little platinate of barium, owing to the platinum crucible being attacked at the high temperature, but after elimination of this impurity the analyses agree very closely with the formula $BaO . CoO_2$. The crystals of this monocobaltite of barium are soluble in cold concentrated hydrochloric acid with evolution of heat, and dissolve likewise in nitric acid with effervescence. At a higher temperature than 1100° they are decomposed with evolution of oxygen gas, the CoO_2 becoming reduced to a lower oxide, probably Co_3O_4, the usual product of the ignition of cobalt oxides. Hence the necessity for keeping the temperature below 1100° during the preparation. If the fusion be simply performed over the Bunsen lamp, another cobaltite is obtained containing two molecules of CoO_2. A crust of crystals of this second compound, $BaO . 2CoO_2$, is formed over the surface of the melt, consisting of brilliant black hexagonal lamellæ. These crystals are likewise soluble in hydrochloric acid with evolution of chlorine gas. In order to avoid the formation of this di-cobaltite it is necessary to maintain the temperature over 1000°, when the neutral monocobaltite is alone produced. Hence the limits of temperature during which the monocobaltite is produced are 1000°–1100°. Thus cobalt resembles manganese in forming a dioxide, capable of liberating chlorine from hydrochloric acid and combining with basic oxides to form cobaltites analogous to the manganites. But this dioxide of cobalt appears from its reactions to be somewhat weaker in its combinations than manganese dioxide, and to form them with greater difficulty, the barium cobaltites above described being as yet the only ones prepared.

THE additions to the Zoological Society's Gardens during the past week include two Crested Porcupines (*Hystrix cristata*), a Desert Buzzard (*Buteo desertorum*), two Natal Francolines (*Francolinus natalensis* ♂ ♀) from South Africa, presented by Captain Henry F. Hoste, R.M.S. *Trojan*; a Common Wolf (*Canis lupus*, juv.) from Provincia de Leon, Spain, presented by Mr. W. S. Lart; four Violaceous Night Herons (*Nycticorax violaceus*), a Green Bittern (*Butorides virescens*), a Dominican Kestrel (*Tinnunculus dominicensis*), a —— Pigeon (*Columba*, sp. inc.) from St. Kitt's, W.I., presented by Dr. A. P. Boon, C.M.Z.S.; two Ocellated Mantis (*Harpax ocellata*) from South Africa, presented by Colonel J. H. Bowker, F.Z.S.; a Wapiti Deer (*Cervus canadensis* ♀), a Peacock Pheasant (*Polyplectron chinquis*), eight Mandarin Ducks (*Æx galericulata*), five Summer Ducks (*Æx sponsa*), two Chiloe Wigeon (*Mareca chiloensis*), six Chilian Pintails (*Dafila spinicauda*), three Australian Wild Ducks (*Anas superciliosa*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE BINARY γ CORONÆ BOREALIS.—Prof. Celoria has recently determined (*Astr. Nach.*, 2904) a new orbit for this difficult binary (Σ 1967), which appears a decided advance upon that of Dr. Doberck's, published twelve years ago. A considerable uncertainty still attaches, however, to the elements, although the star has now been under observation for sixty-three years, and has been watched through nearly three-fourths of a revolution. This is due partly to the circumstance that the orbit is presented to us nearly in profile, and partly to the closeness of the two components. The measures in both elements, therefore, have been difficult to make, and have often been very discordant. Thus some recent position-angles by Engelmann show a systematic difference of 30° or more as compared with measures made at about the same epoch by Schiaparelli and Perrotin. The companion passed its primary on the north side about 1836, reappearing in 1840 on the preceding side. It re-passed the principal star on the south about 1878, and is now again on the following side. Celoria's new elements compare with Doberck's as follows:—

	Doberck.		Celoria.
T =	1843·70	...	1840·508
☊ =	110° 24′	...	113°·47
λ =	233° 30	...	250·68
γ =	85° 12′	...	81·66
e =	0·350	...	0·34827
a =	0″·70	...	0″·63103
P =	95·50 years.	...	85·276 years.

ECLIPSES AND TRANSITS IN FUTURE YEARS.—The Rev. S. J. Johnson, author of "Eclipses Past and Future," and well known as a calculator of eclipses, presented a large manuscript volume to the Royal Astronomical Society a few months ago containing projections and diagrams of eclipses from the year A.D. 538 to the year 2500. He has now published in a little pamphlet the dates of all the eclipses, both of sun and moon, visible in England from 1700 to 2000, with the solar eclipses for the two following centuries, and the larger solar eclipses up to 2500. The transits of Mercury and Venus are also included, of Venus up to 2500, and of Mercury to 2000.

The twentieth century is distinguished by three years in each of which seven eclipses take place. Of these, Mr. Johnson notices two, 1917 and 1935, the latter being particularly noteworthy as showing five solar eclipses, but does not mention the third case, 1985, though calling attention to the rare occurrence of three total eclipses of the moon which fall that year.

The little pamphlet, which is intended as a kind of supplement to the author's larger work, "Eclipses Past and Future," is illustrated by four pages of diagrams showing the greatest phases of the eclipses up to 1949, as seen from London. The diagrams are nowhere explained, and no indication is supplied as to which are solar and which lunar eclipses. It appears that circles on which the eclipsed portion is shown by deep shading, and which are surrounded by a ring of shade, stand for solar eclipses, the plain circles for lunar eclipses.

THE WHITE SPOT ON SATURN'S RING.—M. Terby, who still strongly contends for the reality of the bright white spot next the shadow of the planet on Saturn's ring, quotes, in the *Astronomische Nachrichten*, No. 2910, an observation of Ceraski's made in 1884, as showing that it is not a mere effect of contrast with the shadow. M. Ceraski, on November 1, 1884, noticed a bright white spot on the ring where it touched the planet in a similar position to M. Terby's spot, but the shadow of the planet fell at that time on the other portion of the ring, so that the spot could not be accounted for by contrast.

COMET 1889 *c* (BARNARD, JUNE 23).—The following ephemeris for this object is by Dr. R. Spitaler (*Astr. Nach.* No. 2909):—

For Berlin Midnight.

1889.	R.A. h. m. s.		Decl. ° ′		Log Δ.		Brightness.
July 27	3 51 1	...	49 27·4 N.	...	0·1341	...	0·55
31	4 6 14	...	49 47·6	...	0·1416	...	0·50
Aug. 4	4 20 35	...	50 0·3	...	0·1486	...	0·46
8	4 34 0	...	50 7·0	...	0·1549	...	0·43
12	4 46 29	...	50 8·5	...	0·1606	...	0·40
16	4 58 1	...	50 6·0	...	0·1656	...	0·37
20	5 8 37	...	50 0·5 N.	...	0·1699	...	0·34

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *JULY* 28—*AUGUST* 3.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on July 28

Sun rises, 4h. 20m.; souths, 12h. 6m. 14·0s.; daily decrease of southing, 1·3s.; sets, 19h. 53m.: right asc. on meridian, 8h. 31·6m.; decl. 18° 54′ N. Sidereal Time at Sunset, 16h. 20m.

Moon (New on July 28, 0h.) rises, 4h. 27m.; souths, 12h. 33m.; sets, 20h. 28m.: right asc. on meridian, 8h. 58·4m.; decl. 19° 51′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	3 13	11 19	19 25	7 44·6	22 4 N.
Venus ...	1 1	8 56	16 51	5 20·5	20 20 N.
Mars ...	3 10	11 18	19 26	7 43·1	22 20 N.
Jupiter ...	17 38	21 31	1 24*	17 58·1	23 22 S.
Saturn ...	5 46	13 11	20 36	9 36·7	15 27 N.
Uranus...	11 12	16 42	22 12	13 8·6	6 38 S.
Neptune..	23 56*	7 45	15 34	4 9·8	19 23 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

July.	h.	
28	5	Mercury in conjunction with and 0° 14′ south of Mars.
28	20	Mercury at least distance from the Sun.
29	7	Saturn in conjunction with and 2° 16′ south of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
Algol	3 1·0	40 32 N.	Aug. 2,	1 50	*m*
R Ursæ Majoris ...	10 36·8	69 22 N.	,, 3,		*M*
W Virginis	13 20·3	2 48 S.	July 31,	22 0	*m*
X Boötis	14 19·0	16 50 N.	Aug. 2,		*M*
R Camelopardalis.	14 26·0	84 20 N.	July 31,		*M*
δ Libræ	14 55·1	8 5 S.	Aug. 1,	2 32	*m*
U Coronæ	15 13·7	32 3 N.	,, 3,	0 20	*m*
U Ophiuchi... ...	17 10·9	1 20 N.	July 28,	23 17	*m*
			Aug. 3,	0 2	*m*
X Sagittarii... ...	17 40·6	27 47 S.	July 28,	23 0	*M*
			Aug. 2,	3 0	*m*
U Sagittarii... ...	18 25·6	19 12 S.	July 29,	0 0	*M*
U Aquilæ	19 23·4	7 16 S.	,, 31,	22 0	*m*
η Aquilæ	19 46·8	0 43 N.	Aug. 3,	3 0	*M*
T Vulpeculæ ...	20 46·8	27 50 N.	July 31,	22 0	*M*
δ Cephei	22 25·1	57 51 N.	,, 30,	0 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near δ Andromedæ ...	8	32 N.	Swift; streaks.
,, δ Cassiopeiæ	20	58 N.	,, ,,
The *Perseids*	33	55 N.	,, ,,
The *Aquarids*	340	13 S.	Max. July 28.

GEOGRAPHICAL NOTES.

AN expedition is about to start for the exploration of Central Australia. Baron von Müller is interesting himself in the expedition, which will be under the command of the experienced explorer, Mr. Tietkens, who will also look specially after the botany and mineralogy. The point of departure will be Alice Springs, on the central telegraph line, and the country round Lake Amadeus will be carefully examined.

IT is reported from Brisbane, according to the *Colonies and India*, that the Queensland Government has concluded an agreement with Mr. A. Weston to lead an exploring party into the almost untrodden recesses of the northern portion of the colony, with a view to bringing to light scientific treasures supposed to be hidden there. Mr. Weston has accepted the undivided responsibility of leadership. Messrs. Broadbent and Bailey will be associated with him, and will respectively discharge the duties of collecting fauna and flora. The party will explore the region lying to the north-west of Cairns, including the Bellenden Ker Range and the shores of the volcanic lakes. It is also thought that something may be heard of Leichardt's expedition, traces of which are popularly supposed to be yet found in the back country. Mr. Weston has refused to accept any pecuniary assistance from the Government for his services.

M. A. DELCOMMUNE, who has been exploring several of the affluents of the Upper Congo, has arrived in Brussels. He has brought with him a valuable collection of African products, and some 200 views on the Upper Congo.

THE news that Dr. Macgregor, the Administrator of British New Guinea, has reached the summit of the Owen Stanley Range is of much interest. Since Captain Owen Stanley discovered the range, about forty-five years ago, various explorers have attempted to scale it, but all have failed. The summit reached by Dr. Macgregor is over 13,000 feet, and he reports several peaks almost equal in height. As Dr. Macgregor is a good botanist, his journey is likely to yield valuable scientific results.

DR. ALFRED HETTNER, in a communication to the *Verhandlungen* of the Berlin Geographical Society (No. 6, 1889), on his travels in Peru and Bolivia, gives the results of his observations on Lake Titicaca, which are of some interest. The surface of the lake, he states, has in the course of time been subject to great changes of level. The proof of these changes is to be found in the terraces around the lake. In a comparatively recent geological period, Dr. Hettner believes, the level of the lake must have been 20 metres higher than it is to-day, and the lake must have spread over the great part of the plain which now incloses it, perhaps as far as Lake Poopo. At a still earlier period the level of the lake must have been 200 metres above its present level, but between these stages, as many appearances indicate, the lake must have sunk below that level. The highest position of the lake-level is older than the glaciation of the district, and contemporaneous with a period of strong volcanic activity. The 20-metre high terraces may belong to the ice-period. For the idea of a former submersion below the sea Dr. Hettner can find no support; at the same time, he cannot altogether deny the possibility that at the time of the 200-metre terrace the lake may have had some connection with the ocean.

NITRATE OF SODA, AND THE NITRATE COUNTRY.[1]

II.

WE will now consider the structure of the actual nitrate beds. As before mentioned, there is no nitrate under the flat Pampa; but exactly where the first slopes of the coast range spring out of the plain, there nitrate is found at a small but variable distance below the surface. The width of the belt varies with the slope of the hill, being greatest where the slope is least, and the vertical height of the highest part of the bed appears to vary from 100 to 120 feet above the plain. It is, however, most important to notice that *the beds of nitrate follow the slope of the Pampa, and not a level line.* For instance, the northern extremity of the Pampa is some hundreds of feet higher than the southern portion, but the nitrate beds follow the spring of the hill from the plain, throughout their whole extent.

A very different sequence of beds lies under the slope of the hills from those alternating layers of mud, sand, and gravel which are found under the level Pampa. The surface covering of loose dust and small stones, extending to a depth of only a few inches, is locally known as *chuca* (see Fig. 3). This seems to be a native word, but I have been unable to ascertain its meaning. Below the *chuca* comes a very hard layer of earth and stones, almost compacted into rock, from 1 to 2 feet thick, which is called *costra* (Span. crust). Under this lies the *caliche,* or true nitrate deposit. This is a bed of from 1 to 3 feet thick, usually of a whitish crystalline structure, containing from 20 to 50 per cent. of nitrate of soda, with a residuum made up chiefly of common salt and earthy matter. *Caliche* is an Indian word, and may possibly come from the Aymara word *callachi,* a shell, or skull.

Passing through the *caliche,* a hard layer of stones and earth, compacted with salt crystals, is usually encountered. The Spanish workmen call this "*congelo,*" because it is congealed or concreted by the salt.

After a foot or so of this, there comes finally a bed of soft, loose, *sweet* earth, containing a few very small loose stones, known as *cova.* I could not discover the signification of this word; but the whole method of working a nitrate bed turns round the properties of the *cova.*

A workman, with three or four chisel-pointed bars of iron, hence called a *barretero,* stands on the surface of the ground, and chips out a round hole, about a foot in diameter, down to the level of the *cova.* This hole is called a *tiro,* or charge for

[1] Continued from p. 188.

gunpowder (see Fig. 3). A small boy then scrambles down the hole, and easily excavates the soft *cova* a little under the *congelo*, forming an opening called the *taza*, or cup. The *taza* only is then filled with a slow-burning gunpowder, made of nitrate of soda on the premises, a tamping put into the *tiro*, and the charge exploded. The valuable *caliche* bed is thus simply lifted and partially broken, without being blown into dust; and a party of men separate the nitrate from the worthless beds, and carry it to the factory, or *maquina*.

Caliche varies so much in composition that it is almost impossible to give a typical analysis. One very rich specimen gave:—

	Per cent.
Nitrate of soda...	50
Chloride of sodium	26
Sulphate of soda...	6
,, magnesia	3
Insolubles	15
	100

but a more average sample might be taken to contain one-third nitrate; one-third salt; and one-third earth.

The problem for the manufacturer is to get the nitrate without the salt and earth; and the simple basis of the whole process rests on the fact that, while salt is rather more soluble in cold

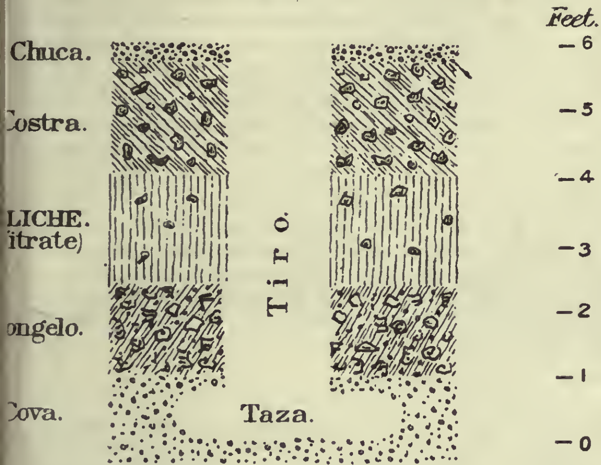


Fig. 3.

than in hot water, nitrate of soda is about four times more soluble in hot than cold water. It is also evident that, if a salty rock is washed with water already saturated with salt, no more of that material can be absorbed. The raw *caliche* is therefore first crushed into small pieces, washed with six changes of hot water, by what is known as the "passing system" similar to that used for lixiviating soda ash. After the last washing the waste *caliche* is known as *ripio* (refuse), and is thrown on to a rubbish heap; while the strongest hot water, which is drawn off the *caliche*, is known as *caldo*, or "broth."

The hot broth then runs for twenty minutes into a settling tank, where earth and salt are deposited, and after that into great square shallow *bateas*, or troughs. In about five days the greater part of the nitrate has been deposited nearly pure at the bottom of the *batea*, and a yellow orange liquid, known as *aqua vieja*, remains on the top. This liquid is drawn off, the nitrate crystals drained, thrown on to a flat floor or *cancha*, to dry for three weeks, and then when bagged are ready for the market.

In many factories the *aqua vieja* is then pumped into the iodine room.

One sample of this fluid gave the following analysis:—

	Per cent.
Nitrate of soda...	28
Sulphate ,, ...	3
Chloride of sodium	11
Iodate ,, ...	22
Sulphate of magnesia	3
Water	33
	100

besides a small quantity of iodide of sodium, which cannot be utilized.

To separate the iodine a mixture of nitrate of soda and coal dust is formed into a pyramid and set alight, by which means a crude carbonate of soda is formed. Fumes of burning sulphur are then drawn through a solution of this carbonate, and an acid solution of sulphite of soda is produced. A suitable quantity of this last liquid is added to the *aqua vieja*, when iodine is precipitated in an impure form, which after sublimation becomes the iodine of commerce.

Nitrate of soda thus manufactured contains from 95 to 96 per cent. of pure nitrate, with less than 1½ per cent. of salt, the remainder being chiefly water. The nitrate is sold in Liverpool for about 10*s*. a hundredweight, while the iodine is disposed of in London for about 3*d*. an ounce.

It is impossible to examine a bed of crude nitrate of soda, without thinking how it got there. We have described the facts as to the position of some beds relative to the lie of the country, and also explained the character of the layers which adjoin the *caliche*, but unfortunately we can do little more. Numerous theories have of course been started, but none have either accounted for all the facts, or obtained general acceptance. This may perhaps be the case because no competent geologist has as yet thoroughly examined the nitrate beds in different parts of the country, but still a few remarks on the subject may be desirable. There is no doubt that the coast range and the Pampa have been elevated out of the sea at a comparatively recent period, but it is also equally certain that since that elevation the climate was at one time far more rainy than at present. All over the plains there are dry river-beds, and the flanks of the hills are scored by water-cut channels which could not have been carved out under the existing conditions of rainfall. This would make it doubtful whether the nitrate could have been deposited immediately after upheaval.

It may be noted as a curious fact that the stones found both in the *costra*, *caliche*, and *congelo* are usually angular; but in one nitrate ground I have certainly seen rounded pebbles in all these formations.

Much difficulty is always found in accounting for the existence of nitric acid. The existence in some deposits of a layer of guano under the *caliche* is a very suggestive fact, but unfortunately our knowledge of the circumstances is far too limited to allow of any generalizations on the subject. The presence of iodine in *caliche* has often been appealed to as pointing to the decomposition of beds of seaweed; but it may be remarked that there is a good deal of iodine about in the neighbouring mountains in the form of iodide of silver. We can only repeat the statement that the origin of nitrate of soda is at present unknown.

Whatever may have been the origin of the beds, there is no doubt that their existence is due to the rainlessness of the west coast of South America, so that a few remarks on the climate and weather of the *caliche* districts may be of interest. All along the coast we find three belts of climate and weather: that of the coast, that of the Pampa, and that of the Sierra.

Iquique may be taken as a typical station on the coast, and here fortunately a considerable amount of material has been accumulated through the labours of the Meteorological Commission for Chili. Speaking broadly, temperature at any season will rarely exceed 80°–85°, or fall below 50° at any hour in the coldest season; and as the air is always tolerably dry the climate is very bearable and wholesome. The wind blows from south to south-west throughout the year during the day, but at night sometimes comes more off the land from some point of east. Though nothing approaching to a gale ever blows at Iquique, the effect of distant storms is often experienced in the form of a heavy surf, which entirely stops any shipment of nitrate. The surf days, or *Bravesas* as they are called, occur most irregularly, for while in some years only nine days are recorded, other seasons have been credited with no less than forty-three days of enforced idleness. Contrary to the usual opinion, three or four slight but real showers fall every year, mostly in the months of June, July, and August, though this precipitation does not extend inland to the Pampa. The sky is usually clear, but a low stratus or strato-cumulus cloud often covers the sea and coast range during the forenoon, but dissipates as the sun gains power.

On the Pampa, where all the nitrate *oficinas* are built, the temperature may rise to 85° or 90° on the hottest days; and at night may fall to the freezing-point during the winter months. The air is much drier than on the coast; and though rain has been known to fall, it is certainly of very rare occurrence. Cloud is more rare on the Pampa than on the coast; but nearly every night a very thick wet fog settles over the plain. This is locally known as *camanchaca*, probably an Aymara word, whose signification I have not been able to find out. The mist is popularly supposed to come from the sea, but this is only partly true. The fog doubtless rolls from the west or seaward side, but the origin is certainly due to local radiation, for the densest mist may lie over the Pampa, when there is no trace of fog on the sea-coast.

The nights and forenoons are usually calm on the Pampa, but about 1 p.m. a moderate wind springs up from the south-west, which falls away at sunset. During the night a light air sometimes blows from the Cordillera; and if the wind comes from the east, the *camanchaca* is immediately evaporated.

The Sierra or Cordillera is strangely enough governed by a totally different weather system from that of the coast; for it rains heavily in the mountains during the summer months of December, January, or February; and I have been assured that whenever it does rain on the Pampa, the precipitation has been blown over from the Sierra. *The extreme dryness of the Pampa is owing to its geographical position between the coast range, whose scanty rainfall occurs in winter, and the Sierra, where heavy rain falls in summer, but the precipitation of neither reaches the plain, which therefore remains a desert.* My own observations on the surface and upper winds along the whole length of the Andes, from Valparaiso to Lima, prove conclusively that the old theory that the dryness of the west coast of South America is due to the south-east trade rising over the Andes, and then descending as a warm dry current, is totally wrong, for I found all the winds over 10,000 feet, either from north-east or north-west.

The Pampa is very healthy, for fever is unknown, and though the heat and drought sometimes affect the liver, and a mild dysentery sometimes shows itself, still both are very amenable to proper treatment. There seems to be only one ailment special to the Pampa and the other nearly rainless districts of South America. This is the so-called "barley blindness" of mules and horses, which manifests itself by a white growth on the pupil of the eye. Absence of sufficient moist food is said to be the cause of this malady, and there is no doubt that if removed in time to a natural pasturage, the affected animal soon more or less recovers its sight.

RALPH ABERCROMBY.

FORTUITOUS VARIATION.

AT a meeting of the Biological Society of Washington (United States), held on December 15, 1888, Mr. Lester F. Ward read a paper on "Fortuitous Variation, as illustrated by the genus *Eupatorium*." He exhibited a series of specimens of that genus, mostly from the vicinity of Washington, and growing in great part in the same kind of soil and under the same general conditions. To simplify the question, the differences in the flowers, heads, and reproductive parts in general, which are less marked in this than in almost any other genus, were ignored, and attention was exclusively directed to the leaves. These, when closely compared, are seen to differ considerably in the different species, the forms ranging from the filiform dissected leaves of *E. fœniculaceum* to the broad ovate leaves of *E. ageratoides*. But between these extremes there are represented in the Washington flora numerous much more similar forms, which present to the observer a strongly marked family resemblance; from those with more elongate leaves, such as *E. altissimum*, *E. album*, and *E. teucrifolium*, through the increasingly broader more ovate forms, *E. perfoliatum*, *E. sessilifolium*, and *E. rotundifolium ovatum* (*E. pubescens*, Muhl.), with an intermediate undescribed form, which Dr. Gray regarded as a hybrid, connecting the last two to the typical *E. rotundifolium*, with its roundish, crenate, but still sessile leaves; and from this last form, with several similar Mexican species, on in the direction of acquiring a petiole, through several exotic forms, to *E. cælestinum*, *E. aromaticum*, and *E. ageratoides*, in an almost unbroken chain of modifications without any apparent advantage to the plants. Almost any other genus might have served the purpose of the paper, but this one seemed to possess the merit of simplicity.

The question naturally arises, in looking at such a group of clearly related forms, all of which, on the modern view, must surely have descended from some common ancestral stock, Why have they varied at all? Why need there be more than one species of Eupatorium in the same restricted flora? Or, if some can be shown to have probably varied in order to adapt themselves to different local conditions, why need there be more than one form occurring under precisely the same conditions? Variation caused by natural selection can only occur where some advantage is secured through it, whereby the new form becomes, by ever so little, better fitted to survive under the conditions of its existence. But here there seems to be no such advantage. It is easy to say that we are incapable of detecting the subtle influences that make one form surer of existence than another. The staunch believer in natural selection may be satisfied with such an explanation, but is it not too much to ask of the new convert or the sceptic? Is not the spread of the doctrine hindered rather than helped by such a demand? Moreover, it was shown that several different forms actually flourish together in the very same localities, and that this is not exceptional, but the common case, so that the idea of special fitness of form to station is precluded. And is it not antecedently improbable that there should be any advantage in a plant's having a sharp-pointed rather than a blunt-pointed leaf, a serrate rather than a crenate one, or a sessile rather than a short-petioled one? Science becomes metaphysics when such questions are discussed.

The speaker proposed to escape from the dilemma by denying that advantage, or fitness to survive, or natural selection, had anything to do with such variations; and he maintained that they were truly fortuitous in the only true sense of that term. By this he did not mean to say that they were due to mere chance in the sense of being without cause; and the remainder of his paper was devoted to an attempt to explain the cause of fortuitous variation. It may be briefly summed up as follows:—

Organized or living matter constantly tends to increase in quantity, which may be regarded as the true end of organic being, to which the perfection of structure, commonly mistaken for such end, is only one of the means. Every organic element may be contemplated as occupying the centre of a sphere, toward the periphery of which, in all directions alike, it seeks to expand, and would expand but for physical obstructions which present themselves. The forms which have succeeded in surviving are those, and only those, that were possible under existing conditions; that is, they have been developed along the lines of least resistance, pressure along all other lines having resulted in failure. Now, the various forms of vegetable and animal life represent the latest expression of this law, the many possible, and the only possible, results of this universal *nisus* of organic being. The different forms of *Eupatorium*, or of any other plant or animal, that are found co-existing under identical conditions merely show that there were many lines along which the resistance was not sufficient to prevent development. They are the successes of Nature.

Mr. Ward disclaimed any desire to discredit or impair in any way the great law of natural selection. The most important variations, those which lead up to higher types of structure, are the result of that law, which therefore really explains organic evolution; but the comprehension and acceptance of both natural selection and evolution are retarded instead of being advanced by claiming for the former more than it can explain, and it might as well be recognized first as last that a great part—numerically, by far the greater part—of the variety and multiplicity, as well as the interest and charm, of Nature is due to another and quite distinct law, which, with the above qualifications, may perhaps be appropriately called "the law of fortuitous variation."

SCIENTIFIC SERIALS.

American Journal of Science, July.—A new Erian (Devonian) plant allied to Cordaites, by Sir William Dawson. This unique specimen from the lower Catskill (Upper Devonian), Wyoming County, Pennsylvania, presents the peculiarity of combining the fructification of the Cordaiteæ with foliage akin to that of Næggerathia, thus connecting two Palæozoic groups which are now considered as allied to Cyadeæ and Taxineæ.—The law of thermal relation, by William Ferrel. The object of these researches is to compare Dulong and Petit's older formulæ and the more recent determination of Stefan with the principal available data derived from experiment and observation, with a view to ascertaining what modifications these formulæ may require in order accurately to represent the true law of relation between the intensity of the radiation and the temperature of a body. It appears generally that neither of the formulæ in question represents the true law of Nature through the whole range of experiments, but that different values are required for different ranges of temperature. To determine the true mean value with greater accuracy experiments upon radiation will have to be made at much lower temperatures than any yet made.—Stratigraphic position of the Olenellus fauna in North America and Europe (continued), by Charles D. Walcott. Since writing the first part of this article the author has completed the survey of all the species known to him from the Olenellus (Lower Cambrian) zone in North America. From a general comparison of this zone with the Ordovician the superiority of the latter in number of species, genera, and families becomes at once apparent. But when the comparison is extended to class characters, the disparity is much reduced, and it is made evident that the evolution of life between the two epochs has been in the direction of differentiating the class types that existed in the earlier fauna. It cannot be asserted that the Olenellus fauna of Europe and North America was contemporaneous, although its relations to the succeeding Middle and Upper Cambrian and Ordovician is everywhere essentially the same, the Olenellus being the basal fauna wherever it has been found.—On allotropic forms of silver (continued), by M. Carey Lea. The properties are given of the two already described insoluble forms of allotropic silver, which differ from normal silver especially in their sensitiveness to light, their brittleness and specific gravities (9·58 and 8·51, the normal being 10·5).—The peridotite of Pike County, Arkansas: Part I., description and general relations, by John C. Branner; Part II., microscopic study, by Richard N. Brackett. Though small in extent, the exposure of peridotite occurring near Murfreesboro, Pike County, is geologically important, as offering a clue to the time and character of the disturbing influences which about the close of the Cretaceous sank the greater part of Arkansas and other contiguous regions beneath the ocean. It is also interesting as being the third reported occurrence of picrite-porphyry in the United States. Its position and topographic features are shown in the accompanying map.—Papers are contributed by T. M. Chatard, on urao, shown to be the true natural form of sodium carbonate; by Edward F. Ayres, on the crystallization of trona (urao), from Borax Lake, California; by G. F. Kunz, on fluorite, amber, opal, and diamond; and by O. C. Marsh, on the discovery of Cretaceous Mammalia by J. B. Hatcher in the Laramie formation of Dakota and Wyoming. There is also a reprint of Mr. James Croll's paper in the Quarterly Journal of the London Geological Society for May 1889, on prevailing misconceptions regarding the evidence of former glacial periods.

In the *American Meteorological Journal* for June, Mr. A. L. Rotch contributes an interesting article on the organization of the meteorological service in Belgium. The Royal Observatory was established in 1826, and deals with astronomy, meteorology, and magnetism. The present net-work of stations consists of three Observatories (including Liége, which is independent of the Royal Observatory), fifty stations of the second order, and about 120 rain-stations. Instruments are generally lent, but the observers are volunteers. The most notable instrument in use is the electrical meteorograph, invented by F. van Rysselberghe, which engraves its indications on metal plates, from which copies can be printed. The recording apparatus can work at any distance from the meteorological instruments.—Lieutenant J. P. Finley gives a chronological table of tornadoes in the State of Michigan for sixty-six years ending 1888, with a chart. The total number of storms observed was seventy-six; the year of greatest frequency, 1886—eighteen storms. The greatest monthly frequency was in May and September, and the prevailing direction of movement, north-east. The publication of these statistics is the more valuable, as we learn from another part of the *Journal* that recent restrictions on the publications of the Chief Signal Office prevent it from issuing Lieutenant Finley's tornado charts.—Prof. F. Waldo has a review on some important tornado literature. The author points out where the most important discussions of the subject can be found, and calls attention to some particular points therein. Most of the authentic accounts between 1835-50 are contained in *Silliman's Journal*, since which time most prominent meteorologists have investigated the subject, especially Loomis and Reye.—Mr. W. W. Harrington contributes an article on the whirlpool theory of storms. The object of the paper is to lay before the readers of the *Journal* the views of M. Faye, as formulated in his work, "Les Tempêtes" (1887), which work was reviewed in our columns. Mr. Harrington offers no opinion upon the theory itself, or upon the criticisms of the same.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, July 15.—M. Hermite in the chair.—Observations of the small planets and of Barnard's comet made at the great meridian instrument of the Paris Observatory during the second half of the year 1888, by M. Mouchez.—Thermic researches on the isomeric nitric camphors and on cyanic camphor, by MM. Berthelot and P. Petit. From these researches it appears that, between Cazeneuve's two isomerous nitric camphors, answering to the formula $C_{20}H_{15}NO_6$, there exists the same difference as between a nitrified body and a nitric ether, or any substance of analogous function; further, that nitro-phenol camphor must be less explosive than the corresponding isomerous body. For cyanic camphor the mean heat of combustion has been determined at 8445·3 calories.—On the decomposition of the sulpho-conjugated acids by means of phosphoric acid, by MM. C. Friedel and J. M. Crafts. On recently resuming their study of this question the authors have found that owing to the secondary reactions the decomposition of the acids in question in presence of sulphuric acid does not usually yield all the hydrocarburets contained in them. But the complete decomposition may be effected by mixing the sodium or potassium salt of a sulphonic acid with a considerable excess of concentrated phosphoric acid at a temperature of 60° Baumé.—On the studies in atmospheric micrography undertaken at the Imperial Observatory of Rio de Janeiro, by M. L. Cruls. Considerable interest attaches to these researches, made in a tropical region and in the immediate vicinity of a large city frequently visited by epidemics. Some of the atmospheric particles, obtained in the usual way, have been photographed M. Morize, of the Rio Observatory, and enlarged by 150, 500, and 1000 diameters. In order to collect sufficient data for comparative purposes, M. Cruls has been authorized by the Brazilian Government to organize a special laboratory to carry out a systematic series of microscopic studies on the site that has been chosen for the construction of a branch of the Rio Observatory.—Observations of Barnard's comet (June 23, 1889) made at the Observatory of Algiers with the 0·50 metre telescope, by MM. Trépied and Sy, on July 1 and 5.—On the Brownian movement, by M. Gouy. The author has studied this phenomenon under a great variety of conditions and with diverse kinds of liquids and particles. It results from his observations that this movement is produced with particles of every description, its intensity diminishing in direct ratio to the viscosity of the fluid and the size of the particles; also that it is a perfectly regular phenomenon, produced at a constant temperature and independently of all external influences. Thousands of particles have been examined, and in no single case has any particle in suspension failed to present the usual movement, with its normal intensity regularly decreasing with the increased size, but not with different kinds of particles, the solid, liquid, and gaseous all behaving much alike under like conditions. This fact clearly shows that the cause of the phenomenon is to be sought, not in the bodies themselves, but in the fluid element, whose internal movement they serve to render visible. Hence the Brownian movement alone of all physical phenomena reveals to the eye a constant state of internal agitation in bodies independently of all outward influences. The fact here established will naturally be associated with current kinetic hypotheses, and may perhaps be regarded as a faint and remote result of calorific molecular movements. In this phenomenon the velocities may be estimated at some microns per second, or about 1/100,000,000 of those attributed to molecular movement.—On the electrolysis of distilled water, by M. E. Duter. These experiments, and especially that conducted with aluminium, point to the inference that there are formed at the negative pole metallic hydrides, which are destroyed by the water with formation of an oxide and liberation of hydrogen.—On the ammonio-cobaltic molybdates, tungstates, and vanadates; separation of cobalt and nickel, and of the cobaltous and cobaltic salts, by Adolphe Carnot. The ammonio-cobaltic salts differ in many respects from the corresponding salts of the cobalt and nickel protoxides. But their respective characters are not, as a rule, sufficiently marked to serve to discriminate and separate these salts. M. Carnot, however, now finds that this advantage is presented by the molybdates, tungstates, and vanadates. In the present paper he deals with the molybdates alone.—On the reactions of oils with nitrate of silver, by M. Raoul Brullé. During his researches on the character of different oils, the author has been led to employ the nitrate of silver as a reagent. The results present remarkable differences in the case of olive, cotton, linseed, colza, and other vegetable oils.—On the egg of the sardine, by M. Georges Pouchet. The author's observations show that the sardine *de rogue* (the small sardine of commerce) is a young fish not yet arrived at maturity, and presenting the greatest irregularity in the development both of the ovaries and the ovules; nor, as a rule, is the size any clue to its state of development.

VIENNA.

Imperial Academy of Sciences, May 9.—The following papers were read:—On the preparation of indol from phenyl-glycocoll, by J. Mauthner and W. Suida.—On amides of carbonic acid (second communication), by F. Emich.—On the knowledge of some non-drying oils, by K. Hazura and A. Gruessner.—On the transplantation of bone, by A. Adamkiewicz.—On nerve-corpuscles in their physiological and pathological state, by the same.—Experiments on the decomposition of albumen by anaërobous micro-organisms, and on the aromatic products of decomposition, by the same.—Contribution to the knowledge of gases developed by the fermentation of albumen, by M. Nencki and N. Sieber.—On the formation of para-lactic acid by the fermentation of sugar, by the same.—On benzoyl-compounds of alcohols, phenols, and sugars, by Zd. H. Skraup.—On the constitution of grape-sugar, by the same.—Experimental researches on the periodic law, Part I, by B. Brauner.—Researches on musical psychology and acoustics, by K. Stecker.—Preparatory studies for a monograph on *Muscaria schizometopa*; Part I, synopsis of genera, by F. Brauer and J. von Bergenstamm.—On the crystals of grape-sugar and optically-active substances in general, by F. Becke.—On new improvements of the usual process of combustion, by F. Blau.—Note on the preparation of mono- and dibromo-pyridin, by the same.—On dry distillation of picolinate of copper, by the same.—On a new test for albuminous bodies, by C. Reichel.—Monograph on the fossorial wasps allied with Nysson and Bembex, by A. Handlirsch.—Embryological researches on Ascomycetes, by H. Zukal.

AMSTERDAM.

Royal Academy of Sciences, June 29.—Prof. v. d. Waals, Vice-President, in the chair.—M. Franchimont stated that, as early as the beginning of this year, he prepared the pentamethylene glycol, its oxide, and an unsaturated alcohol of five C-atoms, by boiling pentamethylene dinitramine with diluted sulphuric acid, as also the bromide agreeing with the glycol; and that M. Dekkers had treated the tetramethylene-dinitramine in the same manner. The properties of the pentamethylene glycol agree with those published a few days ago by M. Gustavson, who obtained this compound by another method. He spoke further of the action of nitric acid on carbonic and nitrogenic compounds, and of the influence exercised upon them by certain atomic groups. As instances of carbonic compounds he cited malonic acid esters and their derivatives; of nitrogenic compounds, all kinds of amides, urethanes, &c., so that the extraordinary strong influence of the group $COOCH_3$ appears most clearly, even in the derivatives of piperidine.—M. Pekelharing treated of the destruction of the virus of anthrax in the subcutaneous tissues of rabbits. Small pieces of gelose with a culture of anthrax bacilli, whether containing spores or not, packed in parchment-paper, introduced under the skin in rabbits, not only do not superinduce anthrax in the inoculated animals, but are themselves deprived of virulence. This is the case even when the wound remains perfectly aseptic, of course without application of any antiseptic matter. Leucocytes penetrate into the packets, but the bacilli or spores are not materially affected thereby. Therefore, next to the phagocytose, whose existence is nowise denied, the action of a dissolved substance for the destruction of bacilli must be taken into account.—M. de Vries read a paper on the spiral torsion in wild teasel (*Dipsacus sylvestris*). In opposition to the prevalent opinion, which regards the cases of spiral torsion (called by Alex. Braun *Zwangsdrehung*) as accidents, the speaker deemed himself justified in regarding this phenomenon as an hereditary variation; and this in consequence of an experiment begun by him in 1885 with two twisted individuals. From the seed of the same about 1650 plants were reared in 1887, among which were again two twisted specimens. The seed of these gave in 1889 above 1500 plants, among which were found a little more than 4 per cent. of twisted individuals. The torsion is, therefore, not only hereditary, but will gradually become fixed by the customary method of artificial selection. From the 4 per cent. twisted specimens the best have been selected for seed-bearers further to improve the race.—M. van Bemmelen mentioned the results obtained by M. Bakhuÿs Roozeboom in the pursuit of his researches concerning the behaviour of salts with regard to water. The normal course of the solubility may be disturbed by the appearance of a second layer of fluid when the salt and water are not mixed in all proportions. Mr. Bakhuÿs Roozeboom succeeded in illustrating the peculiarities of the behaviour in such cases in two examples: $AsBr_3$, and a salt recently detected by M. van Romburgh—

$$C_6H \,.\, NO_2 \,.\, N^{CH_3}_{NO_2} \,.\, OK.$$

BOOKS, PAMPHLETS, and SERIALS RECEIVED

Names and Synonyms of British Plants; G. Egerton-Warburton (Bell).—Swiss Travel and Swiss Guide Books: W. A. B. Coolidge (Longmans).—The Human Foot: T. S. Ellis (Churchill).—The Railways of England: W. M. Acworth (Murray).—Farm Live-Stock of Great Britain: R. Wallace (Edinburgh, Oliver and Boyd).—La Lutte pour l'Existence: L. Frederico (Paris, Baillière).—Modern Views of Electricity: O. J. Lodge (Macmillan).—Traité Pratique de la Thermométrie de Précision; C. E. Guillaume (Paris, Gauthier-Villars).—An Elementary Class-book of General Geography: H. R. Mill (Macmillan).—The Micro-organisms of Fermentation practically considered: A. Jörgensen; edited from the German by G. H. Morris (Lyon).—Useful Rules and Tables, 7th edition: by W. J. M. Rankine; revised by W. J. Millar, with Electrical Engineering Tables, &c., by A. Jamieson (Griffin).—Dianthus: F. N. Williams (West).—Psycho-Physiologische Protisten-Studien: Dr. Max Verworn (Jena, Fischer).—Œuvres Complètes de Christian Huygens, tome deuxième (La Haye, M. Nijhoff).—British Rainfall, 1888: G. J. Symons (Stanford).—Solutions of the Examples in Higher Algebra: H. S. Hall and S. R. Knight (Macmillan).—Timber and Some of its Diseases: H. M. Ward (Macmillan).—Index of Spectra, revised edition: W. M. Watts (Manchester, A. Heywood).—Journal and Proceedings of the Royal Society of New South Wales, vol. xxii. Part 2 (Trübner).—Journal of the Royal Statistical Society, June (Stanford).

CONTENTS.

THURSDAY, AUGUST 1, 1889.

MICROSCOPICAL MINERALOGY.

Petrographical Tables: an Aid to the Microscopical Determination of Rock-forming Minerals. By Prof. H. Rosenbusch. Translated and Edited (with the Author's permission) by Dr. F. H. Hatch, of H.M. Geological Survey. (London: Swan Sonnenschein and Co., 1889.)

DR. HATCH has rendered a great service to English-speaking students by the preparation of this careful translation of Prof. Rosenbusch's very admirable "Hülfstabellen zur mikroskopischen Mineralbestimmung in Gesteinen," which appeared a few months ago. These tables may indeed be regarded as an index or summary to the same author's invaluable "Mikroskopische Physiographie der petrographisch wichtigen Mineralien," the English translation of the second edition of which, by Mr. J. P. Iddings, was reviewed not long ago in the pages of NATURE. The two works together supply a want that has long been felt by English students—namely, a complete summary of all that has been done in the way of making the optical and other characters of minerals available as means of recognizing them when seen in thin sections of rocks under the microscope.

Of the admirably lucid and exhaustive manner in which Prof. Rosenbusch, in these works, has compared, arranged, and not unfrequently verified the results accumulated by Zirkel, Tschermak, Von Lausaulx, Fouqué, Michel Lévy, and a host of other observers, who, during the last thirty years, have followed up the suggestive work of Mr. Sorby, the original founder of the science of microscopic petrology, it is not necessary to speak in this place. Geologists and mineralogists are alike placed under a great debt of gratitude to one who—besides making many original observations of great value himself—has so admirably systematized and correlated the results obtained by a great number of other independent workers; nor can they forget that Prof. Rosenbusch is the founder of the now famous Petrographical School of Heidelberg, in which many of the foremost investigators of this branch of science, now engaged in the study of rocks on both sides of the Atlantic, have been so well trained.

The first attempt at the construction of a series of tables, on something like the same lines as those in the work before us, was made as long ago as the year 1876, by Dr. C. Doelter, of Vienna, a pupil of Prof. Tschermak. It was only three years before this that the earliest endeavours to systematize the results arrived at by the study of rocks, with the aid of transparent sections under the microscope, had been given to the world in Zirkel's "Die mikroskopische Beschaffenheit der Mineralien und Gesteine," and in Rosenbusch's "Mikroskopische Physiographie der petrographisch wichtigen Mineralien": the former dealing more particularly with various characteristic peculiarities of the different rock-forming minerals, as a means by which they may be identified in thin sections; the latter aiming at the utilization of the important results arrived at by Des Cloizeaux and his pupils, in their important determinations of the "optical constants" of minerals, as a basis for the exact diagnosis of the constitution of rocks, under the difficult conditions presented by very thin sections which intersect the crystals in varying and unknown directions. Doelter's tables, appearing after these systematic works, constituted a very valuable addition to the scanty petrographical literature of that day. In this work of Doelter, "Die Bestimmung der petrographisch wichtigeren Mineralien durch das Mikroskop; eine Anleitung zur mikroskopischen Gesteins-Analyse," an attempt is made to construct a mineralogical key, similar to the "keys" published with certain floras, and so familiar to all students of systematic botany. Every mineral observed under the microscope was to be submitted to certain optical tests, and then relegated to a particular class; and by the further applications of the similar tests new points of distinction were to be detected, till at last the species or variety had been correctly identified. The process recommended to be pursued was, in fact, exactly similar to that which is usually followed by chemical students in the work of qualitative analysis.

In 1885, Dr. Eugen Hussak, of Gratz, a pupil of Dr. Doelter, published his "Anleitung zum Bestimmen der Gesteinbildenden Mineralien," in which the same method of procedure is illustrated in greater detail, and with the assistance of many new facts and methods that had been discovered since the publication of Dr. Doelter's tables.

In 1888, MM. A. Michel Lévy and A. Lacroix issued their very valuable work "Les Minéraux des Roches," in which the characters of the rock-forming minerals are also exhibited in a series of tables. In this treatise, the authors—we think wisely—abandoned the idea of making anything like analytical keys for the determination of the rock-forming minerals, and arranged the various species and varieties simply in alphabetical order. Just as few practical botanists or chemists find it necessary to go through the whole of the elaborate schemes of research contained in the text-books, though these may be of much educational value to a beginner, so no student of the microscopic character of rocks is called upon to pursue the exhaustive method of analysis illustrated in the tables of Doelter and Hussak. As a rule, the result of a preliminary examination of a mineral seen in a thin section is to make it obvious that we are dealing with some one out of two or three possible forms; and what the observer most needs for deciding between these, is a statement of the characteristic and distinctive peculiarities of every species, arranged in such a manner as to facilitate reference to them.

Prof. Rosenbusch, in his tables, combines to some extent the methods of his predecessors. The main grouping of the rock-forming minerals is into (1) singly-refracting minerals; (2) doubly-refracting uniaxial minerals (there is an unfortunate misprint in Dr. Hatch's translation of "biaxial" for "uniaxial" in table ii.*b*); and (3) doubly-refracting biaxial minerals. In each of these classes, the several species or varieties are arranged in groups according to their general affinities, and irrespectively of their system of crystallization. Dr. Hatch has very wisely supplemented this arrangement by an alphabetical index, and has thus secured almost the same facility of reference which is so conspicuous and valuable a feature in the tables of Michel Lévy and Lacroix.

If we compare the several series of tables to which we have referred, it is impossible to help being struck by the numerous and important additions which have been made to our knowledge of this branch of science during the last decade. Doelter, in 1876, recognized only 64 species or well-marked varieties of minerals as occurring as rock-constituents; Hussak, in 1885, raised this number to 107; Michel Lévy and Lacroix, in 1888, give 160; and Rosenbusch, in 1889, no less than 162 rock-forming types, although none of the opaque minerals are included in these later works.

Still more striking is the contrast between the earlier and later works of this class, when we come to examine the methods employed for the discrimination of the several species of minerals. In the two later works, the results obtained by the important methods of mineral isolation, first discovered and pursued in the famous petrographical laboratory of the Collège de France, under MM. Fouqué and Michel Lévy, and the methods of micro-chemical analysis so well elaborated by Bořický, Behrens, Streng, and other observers are all made use of. Perhaps the most important and characteristic new feature in the two latest published works will be found in the attempt to substitute exact measurements of the double refraction of minerals, for vague statements as to the intensity of the colours which they give with polarized light. It is perhaps too early to pronounce upon the applicability and practical value of the ingenious contrivances of M. E. Bertrand, and of M. Michel Lévy for determining respectively the index of refraction and the double refraction in the thin microscopic sections with which petrographers have to deal. If, however, the micro-refractometer and the *comparateur* fulfil their promise, it is not too much to hope that the methods of discriminating minerals in cleavage-flakes and thin sections will be as greatly facilitated by the exact determination of their refraction and double refraction as by the study of their positions of extinction or of the optical pictures which they give with convergent polarized light.

We have spoken of these tables as being of very great service as an index or summary of the excellent "Physiographie" of Prof. Rosenbusch, and, indeed, we think their chief value will be realized when they are thus employed in conjunction with that important systematic work. In the treatise itself, it has been possible to point out many important limitations and qualifications of general statements, though these have of course to be frequently omitted in the terse indications necessary for the tabular mode of presentation.

An illustration of the caution which ought to be exercised in applying determinations of the so-called optical "constants" of species as *absolute standards* for the identification of unknown forms is afforded to us in the work before us. In many basalts, like those of Bohemia, there occur large porphyritic crystals of an undoubted amphibole. It has long been known that this "basaltic hornblende" presents some very anomalous characters, especially in respect to its pleochroism and absorption, as well as to the curious chemical changes which it is found in whole or in part to have undergone. The important series of determinations of Michel Lévy and Lacroix, which have been incorporated in these tables by Rosenbusch, show that this form of amphibole is not less anomalous in its double refraction, than in some of its other properties. While the difference between the maximum and minimum indices of refraction in all other forms of hornblende ranges between 0·021 and 0·028, that of the basaltic hornblende is found to be as high as 0·072! Whether this remarkable and anomalous departure from the typical characters of an amphibole can be accounted for by the peculiar and somewhat exceptional conditions under which this particular variety is found to occur, it is not necessary here to discuss. But petrographical students cannot be too frequently reminded that—as the isolation and chemical analyses of rock constituents have so often proved—the minerals in rocks may present important differences from those which crystallize out in veins and cavities, and constitute the "types" of our mineralogical collections. Moreover, even small differences in the proportion of certain chemical ingredients have been shown again and again to exercise a very important influence in modifying the values of the so-called optical "constants."

The great interest of the determinations of Michel Lévy and Lacroix, which are adopted in these tables—and indeed constitute their most novel and striking feature—is derived from the fact that the observations on which they are based were made upon actual rock-constituents, and not upon the large crystals, often of exceptional character, which have hitherto been chiefly employed in investigations of this kind. A reference to the numbers representing the refraction and double-refraction of ægyrine among the pyroxenes, and of the several varieties of the epidotes and scapolites, will show that this remarkable case of basaltic hornblende does not by any means stand alone. We trust that the valuable contributions to our knowledge of the characteristics of the actual rock-forming species and varieties of minerals which have been made in M. Fouqué's laboratory, will be greatly added to in the future:—for by such researches only can we hope that many of the difficulties and anomalies which still surround the pursuit of petrological science will in the end be removed.

With the kind co-operation of Prof. Rosenbusch, Dr. Hatch has been enabled to bring these tables quite up to date; and he has fairly earned the thanks of all students of petrography by the careful and thorough manner in which he has performed his task. JOHN W. JUDD.

THE INFLUENCE OF SNOW ON THE SOIL AND ATMOSPHERE.

Der Einfluss einer Schneedecke auf Boden, Klima und Wetter. Von A. Woeikof. Pp. 1–115. *Geographische Abhandlungen*, herausgegeben von Prof. Dr. Albrecht Penck in Wien, Band III. Heft 3, pp. 321–435. (Wien und Olmütz: Eduard Hölzel, 1889.)

IN a country such as ours, which lies on the borders of a great ocean and a great continent, the protean phases of the weather are so greatly determined for us by causes which operate at a distance from our shores, that the influence of any temporary variation in the condition of the local surface is comparatively unimportant, and, excep locally, perhaps altogether inappreciable. But the furthe we recede from this border-land and penetrate to the interior of the continent, the more influential do such temporary and local variations become; and since also, as a rule, they are there more lasting than in our changeable climate, and take effect simultaneously over vast areas of country, it becomes an important object of inquiry how and to what extent they react on the atmosphere, and indirectly affect not only the local weather, but even that of surrounding regions. In the case of a sheet of snow, attention was first drawn to this question by Prof. Woeikof in 1871, in a paper published in the Transactions of the Russian Geographical Society, in which he endeavoured to show that as regards certain portions of Russia, the spring temperature depends very much on the quantity of snow that has fallen in the previous winter, a snowy winter being followed by a cold spring, and *vice versâ*. In 1878 he adduced further evidence of the effects of snow on the temperature, in a notice of the weather of December 1877, in the *Zeitschrift für Meteorologie*; and in 1880 Prof. Hann and Dr. Assmann, in the same periodical, traced the remarkably low temperature of Central Europe and the persistent anticyclone which lay over that region in December 1879 to the effect of the heavy snow that had fallen in the beginning of the month. In Northern Europe, where snow had not fallen, the temperature was not merely relatively, but absolutely higher, and it lay beyond the limits of the anticyclone.

Meanwhile, in 1877–79, the Indian meteorologists, being unacquainted with Prof. Woeikof's earlier work, had independently arrived at the conclusion that variations in the quantity of the winter and spring snowfall of the Himalaya exercise an important influence on the monsoon rains of the Upper Provinces of India; the consequences of an unusually heavy and especially late snowfall on the mountains being the persistence of dry westerly winds on the plains to the partial exclusion or enfeeblement of the rain-bearing summer monsoon; and it was shown that this sequence of land-winds on the plains after snow on the mountains is a common recurrent feature of the winter and spring months. In consequence, for some years past, monthly reports on the state of the Himalayan snows in the first six months of the year have formed a part of the regular routine of the Indian Meteorological Service, and they have afforded important data for forecasting the character of the monsoon rains.

In 1886 a system of snow reporting was adopted in Bavaria by Dr. Lang, and as the result of Prof. Woeikof's labours, a similar system was established in Russia two years later. In India, the system was established under a general order of the Government in April 1883, and that country, therefore, and not Bavaria, as stated by Prof. Woeikof, has considerable priority in this matter.

In his recent work, referred to at the head of this article, Prof. Woeikof sums up the present state of our knowledge of the influence of a snow-sheet on the soil, climate, and weather. The protection of the ground against frost, which is afforded by a covering of thick and loose snow has long been familiar, and was, indeed, the subject of detailed observation by E. and H. Becquerell in 1879–80; but additional observations of much value are given in evidence on this head, especially an elaborate series carried on during two years at the Russian Polar station Segastyr, in the Lena delta, in N. lat. 73° 23′. At this place, when the ground is covered with snow during more than six months of the year, the temperature of the coldest month at 1·6 metre beneath the ground surface was found to be less than 1° C. below the annual mea temperature of the surface (alternatively snow or soil) exposed to the air, while that of the warmest month was 15°·4 C. above it. The greater part of this difference of the excess and deficiency must be attributed to the non-conducting layer of snow and the protection thereby afforded against radiation and contact with the cold winds.

Of the differential cooling effect of a snow-sheet on the atmosphere, as compared with that of a bare land surface, the systematic evidence hitherto available for a rigorous comparison is less extensive than could be desired, owing to the fact that, until recently, but very few meteorological observatories have recorded the presence or absence of snow on the ground. But it fortunately happens that one first-class Observatory, that of Upsala, has done so for a period of fourteen years, and the discussion of these observations forms one of the most interesting and important chapters in the book. Comparing month by month the mean temperatures of all periods during which the ground was under snow with those with an unsnowed surface, Prof. Woeikof finds that the former are lower in November by 4°·7, in December by 5°·1, in January by 6°, in February by 5°·1, and in March by 5°·2 C., respectively equal to 8°·5, 9°·4, 10°·8, 9°·2, and 9°·4 F. The effect of a snow-sheet in lowering the temperature of the air, and in helping to establish anticyclonic conditions, such as prevailed over Central Europe in December 1879, appears, therefore, to be very considerable.

In another chapter of the work, Prof. Woeikof applies the conclusion thus established to the explanation of certain anomalies in the winter temperatures of parts of Asia and North America, and shows that the lower temperatures coincide with the prevalence of snow, and *vice versâ*. The most striking instance given is that of the Armenian plateau, the mean winter temperature of which, after reduction to sea-level value, would appear to be from 4° to 7° C. lower than that of the lower parts of the Transcaucasian province to the north and east. On the former, the snow lies for four or five months of the year; on the latter there is but little snow, and the mean temperature, even of January, is from 2° to 4° C. above the freezing-point. This exceptional area is well shown on Hann's isothermal chart for the month of January, in the new edition of Berghaus's "Physical Atlas."

In discussing the effect of a thick winter snow-sheet on springs and rivers, a variation is pointed out, which is not without importance in its bearings on some points of physical geography. In latitudes where the winter cold is sufficient to freeze the ground to a considerable depth, if heavy snow falls early in the winter before the cold has penetrated deeply below the surface, the protection thereby afforded allows the ground to thaw by conduction from the lower strata, and the water from the slow melting of the basal snow-layer, and much of that which is produced in the spring thaw, soaks into the soil and affords a supply which maintains the rivers more or less full through the succeeding summer. But if, before snow falls, the soil has been frozen to a great depth, a rapid thaw setting in in the spring floods the rivers and the surrounding tracts, while little or none enters the ground, and but little supply is stored up for maintaining the summer flow.

In this short notice we have been able to indicate only a few of the more interesting topics dealt with in Prof. Woeikof's treatise. The effects of the agent to which he has directed attention are undeniable and far-reaching, and the publication of his investigations should have the result of making the registration of the depth and duration of snow a part of the regular work of meteorological observatories. Other observations of a more detailed character, which he specifies in the course of his work, are also much needed. H. F. B.

THE "CIRCOLO MATEMATICO" OF PALERMO.

Rendiconti del Circolo Matematico di Palermo. (Palermo: Sede del Societa, 1887-89.)

THE "Circolo Matematico" is one of the junior members of the now large family of Mathematical Societies. We have before us Tomo I., which gives an account of the proceedings from March 1884 to July 1887. Tomo II. contains like matter for 1888, and of the current volume we have three parts, each of which contains an account of the proceedings for a period of two months, terminating with June last. The first general meeting of which there is any record was held on March 20, 1884, and in that year eleven meetings are recorded, and the proceedings published within the narrow limits of thirteen pages: it was then the day of small things, and we presume the gatherings were confined almost to conversational expositions of mathematical problems. With increase of days came increase of strength, and the first volume contains seventy communications from twenty-one authors; of these the only foreign contributors are Messrs. E. Catalan, F. Cavallaro, Hirst, and Schoute. Dr. Hirst's short note is "Sur la congruence Roccella, du troisième ordre et de la troisième classe," and in it he points out that Dr. Roccella's congruence is a particular case of the Cremonian congruences discussed by him in his memoir "On Congruences of the third order and class" (L. Math. Soc. Proc., vol. xvi., 1885). These congruences are also the subjects of papers read by Signor Guccia. Amongst the longer papers in this volume are: "Intorno ad alcune formole nella teorica delle funzione Ellittiche," by Signor Albeggiani; "Sulle superficie dell' n^{mo} ordine immerse nello spazio di n dimensioni," by P. del Pezzo; "Sopra un metodo per formare le equazioni a derivate parziali, delle superficie che ammettono una generatrice di forma costante," by M. Gebbia; "Sopra alcuni sistemi lineari di curve piane algebriche di genere *due*," by V. Martinetti.

In the second volume there are thirty-nine papers by twenty-six authors. The only long papers are: "Intorno alle curve razionali d'ordine n dello spazio a $n-1$ dimensioni," by G. Loria; "Sul carattere aritmetico dei coefficienti delle serie che soddisfano ad equazioni lineari differenziali o alle differenze," by S. Pincherle; "Sur la marche du cavalier," by C. Jordan. These papers are of no great length; the remaining communications rarely exceed four or five pages.

The May–June number of this year contains a "Solution du problème de Malfatti," by M. Lebon, and an "Étude d'un déplacement particulier d'une figure de forme invariable par des procédés élémentaires et purement géométriques," by M. Mannheim. In selecting papers we have had regard mainly to those which may be called memoirs; the smaller notes treat of similar matters, so that it is readily seen that the field at present occupied by the "Circle" is that of pure mathematics.

The names of the majority of the contributors are well known by their writings in other journals, and their work here is in all cases interesting, and of a high class. A peculiar feature of these volumes which strikes us is the amount of space devoted to the "Biblioteca matematica." In Vol. II., 236 pages are given up to the usual matter of a Society's Proceedings, and 83 pages to the titles of papers, &c., presented to the Society by individuals, or contained in the journals for which the *Circolo* exchanges its Proceedings. This is a useful piece of work, as the circle of exchanges is a large one. We wish the junior member every success.

OUR BOOK SHELF.

Names and Synonyms of British Plants. By G. Egerton-Warburton, B.A. Pp. 160. (London: G. Bell and Son, 1889.)

THIS little book is a synonymic catalogue of the British flowering plants and vascular Cryptogamia, in which are given the names under which the species stand in the last edition of the four standard hand-books, Sowerby's "English Botany," Hooker's "Student's Flora," Bentham's "Flora," Babington's "Manual," and in the London Catalogue. In a considerable number of cases the five differ more or less in the names which they adopt. This arises partly from the five authors taking a different view of specific limits. About two hundred of what Sir J. D. Hooker and Dr. Boswell call sub-species are usually regarded as species by Babington and as varieties by Bentham. The whole series of genera has lately been revised and redescribed by Mr. Bentham and Sir J. D. Hooker, and many which have been proposed by other authors are now placed as sub-genera or sunk altogether. In the preparation of the great Darwin catalogue of plants, under the editorship of Mr. B. Daydon Jackson, the priority of names has been more systematically investigated than has ever been previously attempted, and this has led to a great many changes. These are embodied in the last edition of the widely-used London Catalogue; but as the new or revised names stand there without any explanation, those who wish to use the list are often greatly puzzled, and it was a good idea of Mr. Warburton to prepare the present synonymic catalogue. It appears to have been drawn up very carefully, and gives a reference to the page or number indicating where in each of the five books every species will be found, and in an appendix there is a list of synonyms used by older British or Continental authorities. There is also a full list of the original authorities for the specific names, with the titles and dates of the books and papers in which the plants were originally described. The author omits to enumerate in his list two very useful books, the "Conspectus" of Nyman, and "Salictum Woburnense" of Forbes. He has failed, and no wonder, to run down some of the London Catalogue names of Rubi (*e.g.* *echinatus* and *longithyrsiger*), that refer to long-known plants, fully described in Babington's "Manual and Synopsis." J. G. B.

Geology in Systematic Notes and Tables for the Use of Teachers and of Taught. By W. F. Gwinnell, F.G.S., F.R.Met.Soc., &c. (London: Allman and Son, 1889.)

WHILE we cannot but regard the chief educational value of summary statements of the bare facts of a science, like those contained in the work before us, as consisting in the influence they exercise on the thought and memory of him who compiles them, yet it is impossible to ignore the fact that, in these days of many examinations, there is a persistent demand for works of the class. It is well, therefore, that books of the kind should be prepared with reasonable intelligence, and with such care against the propagation of glaring and misleading errors as the author of this work has certainly shown. It would undoubtedly be better that the *teachers* should prepare their own lecture-notes, with illustrations derived from personal reading and study; and no less desirable is it that the *taught* should make such notes of the facts referred to in illustration of the lessons given them, as to be able to recall to their minds the arguments of the teacher, and the principles which he has aimed at enforcing. For teachers and students who are incapable of following this very obvious and desirable method, however, notes and tables of the kind before us certainly have their use. Mr. Gwinnell's book is happily free from the gross absurdities and mistakes so common in many of the books prepared with the avowed aim of meeting the wants of those preparing for examination; and, for those who must have a crutch, we may admit that this is a very excellent one of its kind. We have noticed a few unfortunate errors, such as the statement that granitite contains pink orthoclase, and that graphic granite consists of "quartz and felspar arranged in lines like writing." The pretty geological map of Great Britain forming the frontispiece, too, which has been adopted from a work that appeared a good many years ago, exhibits nearly the whole of the Scottish Highlands as consisting of Lower Silurian rocks. On the whole, however, the book has the merit of being accurate and up to date, and the author is entitled to the praise of having very carefully selected, arranged, and verified the mass of miscellaneous information which he has brought together.

La Période Glaciare: Étudiée principalement en France et en Suisse. Par A. Falsan. (Paris: Felix Alcan, 1889.)

THIS volume, which is the most recent addition to the collection of the "International Scientific Series," published in the French language, contains a most admirable *résumé* of facts and opinions bearing upon the Glacial period, as illustrated in France and Switzerland. The author shows a very extensive acquaintance with the immense body of literature dealing with glacial questions, by English, American, German, and Scandinavian geologists; and very fairly and temperately discusses the bearings of the numerous theories that have been put forward upon the facts observed in France. As the references to original memoirs are very full and complete, the work cannot fail to be of much value to glacialists and geologists in general, while it admirably fulfils its main object, that of giving an accurate and popular account of the current knowledge and opinion of geologists upon glacial questions, especially adapted to the want of French readers.

Even when compelled to express his dissent from extreme views upon such questions as the recurrence of glacial periods in past geological times, the influence of glaciers in excavating lake basins, and the existence of man in Tertiary times, M. Falsan clearly states the grounds on which conclusions different from his own have been arrived at by other authors. In his presentation of the arguments for and against the various glacial theories, his moderation and his fairness are alike conspicuous.

The author of this book has taken an active part in the important work of preserving the most conspicuous of the fine boulders scattered over France; and numerous sketches of these boulders, with many interesting details concerning them, find a place in these pages. Two plates, a map showing the former extension of the French glaciers, and a series of sections illustrating the former dimensions of the Rhone Glacier, accompany the work; but the other engravings are wanting in the beauty and finish so often found in books published in France. The very full table of contents does not compensate for the total absence of an index to the book.

Physiological Diagrams. With an Index. By G. Davies. (Edinburgh and London: W. and A. K. Johnston, 1889.)

THESE diagrams are designed for use in schools, and to "supply the teacher with a means (by teaching the pupils to draw from them) of impressing the form and organs of the different parts of the body on the pupils' minds." There are nine in all (each 22×30) printed in black upon cardboard, with eyelet holes for hanging purposes. The parts are represented in hard outline, each being numbered, in accordance with a series of explanatory reproductions in miniature, which accompany the "text." The whole production is most feeble. It is only when the author relies upon standard works that his diagrams are tolerable, and his only really useful sheet (No. 1) is a copy. Seeing that much better wall diagrams have long been before the public, we are at a loss to see any *raison d'être* for these poor apologies. We are told that "the principal object of these drawings is to facilitate the teaching of physiology in schools." So much the worse for the schools! We cannot congratulate either author or publishers upon their venture. The day is past in which anything in outline will pass current for an atlas; and pictorial aids to the teaching of elementary physiology, to be of any service, must be produced by competent authorities.

Woolwich Mathematical Papers, 1880–88. Edited by E. J. Brooksmith, B.A., LL.M. (London: Macmillan and Co., 1889.)

IN this book we have a collection of the various papers in mathematics prepared during the last eight years to test the knowledge of candidates for admission into the Royal Military Academy. The subjects are: geometry, arithmetic, algebra, plane trigonometry, statics, and dynamics. The volume will prove most useful to those who intend entering for these examinations, and will also be of service to many teachers in our public and private schools. The answers to the examples in the various papers are collected together at the end.

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.*]

Head Growth in Students at the University of Cambridge.

UNDER the above heading there appeared in NATURE, vol. xxxviii. p. 14, an article in which certain very weighty conclusions are drawn from grounds which I hope to show are quite inadequate. These conclusions are as follow:—

(1) Although it is pretty well ascertained that in the masses of the population the brain ceases to grow after the age of 19, or even earlier, it is by no means so with University students.

(2) That men who obtain high honours have had considerably larger brains than others at the age of 19.

(3) That they have larger brains than others, but not to the same extent, at the age of 25; in fact, their predominance is by that time diminished to one-half of what it was.

(4) Consequently "high honour" men are presumably, as a class, both more precocious and more gifted throughout than others.

These conclusions were deduced from measurements taken in the following way. The maximum length, width, and height (above a specified plane) of the head are taken in inches and decimals of an inch. Since the quantities lie between 5 and 8 inches, each measurement is open to an error of from 1·3 to 2·0 per cent.

The product of these three is found, and is supposed proportional to the cranial capacity. That this is most imperfectly so in individuals is manifest; but the author hopes that in the average of a large number of cases the effect of the extreme variability of shape of the head may be obliterated. He therefore tabulates the products, using the first decimal place, *i.e.* up to four significant figures. Since the original measurements only included two figures, the last two of the four must be inaccurate. The product is open to an error of 3 or 4 or even up to 6 per cent. Since the probable error is from 3 to 6 per cent., which is nearly the same size as the difference between the "honour" man's and "poll" man's heads, and also the difference supposed to be due to growth, I therefore hold that there is no evidence for any of the author's conclusions.

I have recently had a better opportunity of judging the value of the statistics, for two of my friends, who have been several times measured, have kindly shown me the results.

	Width.	Length.	Height.	Product.
X., June 1888	5·8	7·7	5·6	250·1
,, Nov. ,,	5·9	7·8	5·2	239·3
,, Dec. ,,	5·9	7·7	5·5	249·9
,, Jan. 1889	5·8	7·6	5·4	238·0
,, March ,,	5·8	7·6	5·4	238·0
,, May ,,	5·8	7·7	5·3	236·7
,, June ,,	5·8	7·8	5·5	248·8
Y., Jan. 1888	5·9	7·5	5·6	247·8
,, March ,,	6·0	7·4	5·4	239·8
,, Aug. ,,	6·0	7·6	5·5	250·8

From the above table it will be seen that (1) in the measurements of the same individual taken at different times the width may vary 0·1 inch; (2) the length may vary 0·2 inch; (3) the height may vary 0·4 inch; (4) the above variations are not due to head growth, for they are as often negative as positive.

As anyone would expect who had seen the instrument used, the height measurement is most unsatisfactory. The error of 0·4 inch is not an isolated case. Yesterday another friend of mine, who was measured for the second time, found that his height of head had apparently decreased 0·5 inch.

The products are seen to vary in the first case from 236·7 to 250·1, nearly 6 per cent. So far are the figures capable of affording good evidence of head growth of either individual, they are so inaccurate as not to make certain whether X. or Y. had the bigger head. It is quite evident that numbers, each open to an error of 5 or 6 per cent., cannot, when combined into averages, teach us anything about differences as minute as 3 per cent.

Trinity College, Cambridge, July 16. F. M. T.

THE errors made in measuring the height of the head are certainly much larger in the instance given by "F. M. T." than they should be; still they do not seem to me large enough to throw doubt on the truth of the general conclusions to which he refers. (1) As regards the difference between the means of the "products" in the high honour and the poll men. Those means are 224 and 237, and they depend on 258 and 361 observations respectively, which numbers are much the same as 16^2 and 19^2. Therefore the probable error in the determination of each of these means will be equal to the probable error of a single "product" divided by 16 in the one case and by 19 in the other. I have as yet no data to determine the probable error of a single "product," due to faults of measurement alone, other than those given by "F. M. T.," which suggest, though in the rudest way, that it is about 4 units. Accepting this for the moment as a basis, the probable error of the means of the two sets of "products" would be 4 divided by 16 and by 19, equal, say, to $\frac{1}{4}$ and $\frac{1}{5}$ respectively. Now, the chance of an error exceeding 4 or 5 times the probable error is not worth regarding; therefore safety, so far as regards the effects of inaccuracy of measurement, is practically to be found in each mean value beyond a range of about 1 unit. In the differences between the mean measures, safety will be found beyond the range $\sqrt{2}$, say $1\frac{1}{2}$ units. But the two means 224 and 237 differ by as much as 7 units. It should, however, be remarked that the seven observations fall into two well-marked groups, each of which is very consistent within itself, but which differ from one another by 10 units. This raises strong suspicion of some peculiarity in the shape of the head, which caused doubt as to the exact line of maximum height, and that one line was followed in three of the measurements and another line in the remaining four. (2) As regards the differences between the high honour and the poll men at different ages, the observations at each stage are, of course, much less numerous than in the sum of all of them, still they range in all cases but two between 25 (or 5^2) and 102 (or say 10^2). Each person must judge for himself, from the diagram that accompanied my little paper, how far the run of those differences confirms my conclusions. I think they do well enough to give "an approximately true" idea of what we should find if we had the opportunity of discussing a much larger number of observations, and this was all that I claimed.

The remarks of "F. M. T." lead to two useful deductions. One is the desirability of checking, as soon as may be, the conclusions already reached, by discussing the observations that have since accumulated. The other is to improve, if possible, the method of measuring the height of head. The existing plan was adopted, after consultation with many competent persons, and many trials, as the best then available for making this very difficult measurement. I have, however, never ventured to introduce its use in my laboratory at South Kensington.

FRANCIS GALTON.

Intermittent Sensations.

IN a short notice in NATURE of May 23 (p. 86), calling attention to the intermittence of the intensity of some sensations, and more particularly to the experience of M. Couetoux as reported in the *Revue Scientifique*, the writer very properly remarks, that these sensorial fluctuations deserve more thorough study. It may interest him, therefore, to learn that the interrupted sensibility of the retina can be easily demonstrated, to anyone possessed of binocular vision.

Some years ago, on converging the eyes, so as to fuse the images of two squares, each square being composed of parallel lines 1 mm. broad with an equal interval between them, and the lines in one square being perpendicular to those of the others, I was astonished to find that instead of squares, which ought to have resulted from the perfect fusion of the two images, the field was occupied by a series of zig-zags, composed of portions of straight lines of each square, passing across the field sometimes from right to left, sometimes the contrary way, and too complex and transitory to admit of analysis.

Since your notice, while experimenting with my students with a stereoscope, we have obtained the same result in every case. But, in order to determine the rate of intermittence, the attention was fixed on a small mark made in the centre of one of the squares.

This mark was found, on an average of a number of experiments by different individuals, to be visible, with its accompanying lines, for from 6 to 8 seconds, and then completely extinguished; and the lines of the other square, appearing for an equal interval of time, thus completed the cycle of activity and rest in from 12 to 16 seconds.

On covering the eye not directed to the mark, this point was never entirely lost sight of, but went through a series of changes of brightness and degradation of the sensorial impression, corresponding in time with those of the previous experiment.

These experiments seem to show that the impression is not equally intense, at the same instant, over the surface of each retina, but occupies successive areas, in somewhat irregular patches, which appear to be supplemented by the other retina in binocular vision It is probably due to this that the imperfect images of objects formed on the retina are corrected, and our perceptions made more accurate than they would be if our sensations were not intermittent. THOMAS REID.

11 Elmbank Street, Glasgow.

The Aurora.

THE aurora in the Unites States is rarely seen at a single station for two nights in succession, but is usually reported from different stations for about four days at each manifestation. Recurrence at intervals of nearly twenty-six days is common.

During 1888 there were eighteen instances of this, in which the beginnings of the attendant magnetic perturbations, as shown by the self-recording magnetograph, were so abrupt that it was possible by this means to determine the time of the revolution of the sun, the average period thus found being twenty-six days and eight hours.

This behaviour of auroras and magnetic storms indicates that any solar disturbance which may originate them has this power during a limited portion only of its transit across the earthward side of the sun. From April 1886 to April 1889 inclusive, there were in this country 188 such characteristic outbreaks of the aurora. In twenty-six, observations were lacking; but in the remaining 162, in every instance, bright faculæ with or without dark spots are known to have been located upon the sun's eastern limb appearing by rotation. In those instances in which a disturbance appearing by rotation failed to originate an aurora, there was, as a rule, an increase in the number of stations reporting thunderstorms. Indeed, at such times there was always an increase of thunderstorms, although the aurora when at its height not unfrequently seemed to take their place, causing a temporary decrease. From this it follows that the appearance upon the sun by rotation of spots or faculæ is a condition upon which the appearance of the aurora or increase of thunderstorms to some extent depends. M. A. VEEDER.

Lyons, New York, July 17.

Do Animals Count?

HAVING studied Sir J. Lubbock's interesting book, I remembered a fact observed by me, which, though it is not conclusive, seems worth mentioning. I was amused some years ago to observe the feeding of the young in a sparrow-house near an upper window of my house. The old sparrow alighted upon the small veranda of the sparrow-house with four living cankerworms in his beak. Then the four young ones put out their heads, with the customary noise, and were fed each with a caterpillar. The sparrow went off, and returned after a while again with four living cankerworms in his beak, which were disposed of in the same manner. I was so interested and pleased with the process that I watched it for some time and during the following days.

A fact which I have not seen noticed here in the extensive sparrow literature, is that for a number of years sparrows begin to build nests of dry grass and hay at the top of high trees. The first I saw were large irregular balls placed on the tripod of twigs. The entrance was on the inner side near the lower end of the balls. Last year, I observed another form of the nests. A strong rope formed of dry grass, as thick as a man's wrist and as long as the forearm, is fastened only with the upper end to strong branches at the top of high trees. The rope's end has a rather large ovoid shape with the entrance to the inside near the end. Of such nests I saw last winter about a dozen on the elms here in Main Street, near the College grounds, and similar ones in Putnam Avenue and other streets. A long pole near my house strongly covered by a vine (*Celastrus scandens*) had such a nest for three years, used every year.

In the sparrow-houses around my lodging the sparrows stay throughout the winter; commonly one male and three females in every house, till in spring the superfluous females are turned out. H. A. HAGEN.

Museum of Comparative Zoology, Cambridge, Mass., July 15.

The "Hatchery" of the Sun-fish.

THE fact that the "sun-fish" of the American lakes and streams prepares a place for the deposit of its eggs and guards them till hatched is widely known. Certainly is has long been known and is recorded in all recent American works on fishes. The first detailed statement of its nidification I know of was published by Dr. John D. Godman, in his "Rambles of a Naturalist," about 1830, and is reprinted with the third and succeeding editions of his "American Natural History," published in 1836, &c.

Another quite full account of its nest-building and care of the eggs was published, with an illustration, by the late Prof. L. Agassiz in the Proceedings of the American Academy of Arts and Sciences (vol. iii. pp. 329, 330, 1857). But the accounts of Godman and Agassiz, as well as all others, and my own observations, fail to agree with those recorded in NATURE (June 27, p. 202). The sun-fish, generally at least, simply clears a subcircular area whose diameter is usually about two or three times its own length, and therein the female deposits her eggs. It has generally been assumed that she alone or she and the male in turn guards the nest. The idea, however, is only the result of analogy from the observation of the higher vertebrates. It is quite likely that the male fish is usually the guardian of the nest, as in the case of the Gasterosteids, Cichlids, and Silurids.

It should be added that the American sun-fish, although called in some places roach and bream, is not at all related to the English fishes so named, but is the representative of a family (*Centrarchidæ*) peculiar to and quite characteristic of North America. This family is exemplified by about forty species, referred to ten or eleven genera. The only species observed in the Adirondack region is the *Eupomotis gibbosus*, generally known to European naturalists as *Pomatis vulgaris* or *auritus*. The family is closely related to the Percids, and is indeed considered to form a part of the latter by many naturalists, and has nothing to do with the Cyprinids, to which the roach and bream belong. THEO. GILL.

Washington, July 17.

Centrifugal Force and D'Alembert's Principle.

I agree so cordially with the greater part of Prof. Minchin's address to the Association for the Improvement of Geometrical Teaching, delivered on January 19, 1889, and reported in NATURE of June 6, p. 126, that I feel the more induced to enter a protest against his remarks on the subject of "centrifugal force."

I admit that the name is not well chosen, and is often misunderstood, but I contend that we want a name for certain forces which are now called centrifugal, and which, until a better name be suggested, we can do no better than to continue to call by that name.

If a train, passing round a curve at too great a rate, tears the rails from the sleepers, we want a name for the force producing this effect. When a train, running over a horizontal girder bridge, produces a deflection greater than that due to its weight, we want a name for the force producing this extra strain.

The popular mistake is in regarding centrifugal force as a force imparted *to* a body whose motion is being deflected, instead of being imparted *by* such a body.

When a wet mop is trundled, for example, the water does not fly from it owing to centrifugal force, but owing to want of sufficient centripetal force to keep it back.

Prof. Minchin says:—"If we imagine a stone to be attached to an elastic string, one end of which is tied to the hand, while the stone is projected vertically upwards, the hand would experience an *upward* pull. Are we thence to conclude that the stone is continually acted on by an *upward* force?"

From this illustration Prof. Minchin obviously objects to the term "centrifugal force" as meaning a force imparted *to* the body whose motion is being deflected. In this he is certainly right, but this is no objection against its legitimate use as a force imparted *by* such a body.

Clerk Maxwell ("Matter and Motion," p. 97), says that "in some popular treatises centripetal and centrifugal forces are described as opposing and balancing each other. But they are merely different aspects of the same stress." Just so. But because two classes of forces are different aspects of the same stress, why, if sufficiently common and important, should they not have distinctive names given them?

What I understand by centrifugal force is the reaction against a force deflecting a body's motion.

Knowing the objections which have been raised to the use of the term centrifugal as denoting such forces, I have endeavoured to find some unobjectionable equivalent for it. For *centripetal* force (which, strangely enough, is not generally objected to), I have found what seems to me a fair equivalent, viz. *normal force*, defining force as *normal* when it produces deflection only, and *tangential* when it produces change of rate only, but I have never been able to find a better name than centrifugal for the reaction against normal forces.

Prof. Minchin traces back what he considers to be the "fallacy" of centrifugal force to D'Alembert's principle, to which he objects as "unnatural and unnecessary." I do not think he will get many to agree with him in this view. The hypothetical reversal of the resultant forces in D'Alembert's principle may be unnecessary in the sense that we can do without it; but as it enables us to avoid the consideration of those changes in forces which are functions of the positions of their points of application, it is to be regarded rather as an ingenious device, unnecessary perhaps now that we have learned to distinguish power from work—that is, the fluxion from the fluent—but very useful when the ideas of power and work were confused together, as until lately they have been. At present it would perhaps be better to enunciate D'Alembert's principle as follows:—

"The algebraical sum of the powers of the external forces of a passive system is equal to the sum of the powers of the resultant forces." A *passive system*, for any motion, being defined as "one the sum of the powers of whose *internal* forces for that motion, is zero." F. GUTHRIE.

South African College, July 2.

"The Theorem of the Bride."

DR. ALLMAN would be doing a service if he could trace the *origin* of this term (see NATURE, July 25, p. 299). Its occurrence in the "Scholia" carries its use back to an early date, but hardly far enough. R. T.

RECENT RESEARCHES INTO THE ORIGIN AND AGE OF THE HIGHLANDS OF SCOTLAND AND THE WEST OF IRELAND.[1]

II.

III.—*The Silurian Period.*

AFTER the long interval of time represented by the elevation of the red sandstones into dry land, and their entire removal from some places by denudation, the north-west of Scotland, and probably a large tract lying around it, sank under the sea. The depression seems to have been slow and gradual, and to have continued until the site of the Cambrian basins and of the surrounding region was covered with a considerable depth of clear open sea-water. The records of this subsidence are contained in a series of strata having a total thickness of somewhere about 2000 feet, and divisible into two chief groups—a Lower, composed of quartzites, grits, and thin conglomerate, about 500 feet in total depth, and an Upper, consisting almost wholly of limestone. Perhaps the most striking feature in this series of stratified rocks is the abundance of their organic remains. The quartzites are crowded with the tubes formed by sea-worms when the material existed as soft white sand on the sea-bottom. The limestones are made up of the remains of calcareous organisms, among which the most conspicuous that now remain are chambered shells and Gasteropods. Throughout these limestones, worm-casts are present almost everywhere, and in such abundance as to show, as Mr. Peach has pointed out, that "nearly every particle of the calcareous mud must have passed through the intestines of worms." A large collection of fossils has been made by the Geological Survey from these limestones, which, though not yet specifically determined, amply confirm the original generalization of Salter, made more than thirty years ago, that the aspect or facies of organic remains in the limestones of the north-west of Scotland resembles that of the older parts of the Lower Silurian formations of Canada rather than that of the corresponding rocks in Wales. So marked is the resemblance to the American type as to indicate that some shore-line must once have stretched across the North Atlantic, in order to afford a platform for the free migration of marine life between the two areas. The contrast with the Welsh type has been explained by the probable existence of some barrier that separated the sea-bed over the north-west of Scotland from that of Southern Scotland, England, and Wales. That such a barrier existed is tolerably certain, and I shall presently refer to some indications of its probable position. At the same time it may be open to question whether the Durness limestones can be properly correlated as homotaxial equivalents of any Lower Silurian rocks in Wales. My own impression is that they may be older than the oldest Arenig rocks, and may be equivalent to some part of the "Primordial Silurian" or Cambrian series. This, however, is a question that must remain unsettled until a thorough critical examination of the fossils has been completed.

The area within which these Silurian quartzites and limestones can be certainly recognized forms a narrow belt extending for about 110 miles along the north-west coast of Scotland, from the northern coast of Sutherland to the south of the Island of Skye. Throughout that extent of ground the rocks exhibit remarkable persistence in the character and thickness of their several subdivisions, whence the inference may legitimately be drawn that the area within which they are now visible forms but a small part of the region over which they were originally deposited.

It was claimed by Murchison, and generally conceded by geologists, that the quartzites and limestones of the north-west pass upward into a younger series of schists, representing metamorphosed sedimentary rocks. This order of succession appeared to be established by the evidence of many clear natural sections along the whole tract from Durness to Skye. It was first adopted and afterwards opposed by Nicol, who in his later papers maintained that the supposed younger schists were merely the old or Archæan gneiss brought up again by great faults, and pushed over the younger formations. But he failed to account for the striking difference in petrographical character between the old gneiss and the younger schists, and for the remarkable coincidence between the general dip of the latter and that of the Silurian stratified rocks on which they seemed to rest conformably. During the last ten years, various geologists have renewed the investigation of the question, among whom I may specially mention Dr. Hicks, Prof. Bonney, Dr. Callaway, Prof. Lapworth, and the members of the Geological Survey, particularly Messrs. Peach, Horne, and Clough. The result of their labours has been, in the first place, the discovery of one of the most complicated pieces of geological structure at present known in any country; in the second place, the abandonment of all further controversy, and the attainment of complete harmony regarding the order of geological succession in the North-West Highlands.

Murchison's view that there is a regular upward passage from the quartzites and limestones into the upper schists is proved to be erroneous, while Nicol's contention that the old gneiss is brought up again above the Silurian rocks is found to be, so far, correct. But the structure is now seen to be infinitely more complex than Nicol imagined, while, on the other hand, Murchison's belief that the younger schists were evidence of a gigantic metamorphism later than Lower Silurian time is undoubtedly true, though in a sense very different from that in which he looked at the question.

Nowhere in the North-West Highlands can any rock be seen resting in its original and natural position above the limestones. The highest limestone of Durness is the youngest rock of that region about the geological position of which there is any certainty. At present we know absolutely nothing of other sedimentary strata which followed that limestone. That such strata continued to be deposited is certain, for the changes which the quartzites and limestones have undergone could not have taken place save under the pressure of a thick mass of overlying material. But this superincumbent mass has been entirely obliterated in the extraordinary series of terrestrial movements which I have now to describe.

[1] The Friday evening lecture delivered at the Royal Institution on June 7, by Dr. Archibald Geikie, F.R.S. Continued from p. 302.

IV.—*The Period of the Younger Schists.*

Without entering into details, which are only intelligible with the help of a large map and sections, and even with this aid involve much disquisition of a technical kind, I may briefly say that after the deposition of the limestone and of the missing strata, whatever these may have been, which covered them, the whole region was convulsed by a series of disturbances, to which there has since been no parallel within our borders. By a series of intermittent movements the terrestrial crust, for thousands of feet downward, over the North-West Highlands, was fissured and pushed bodily westward. The various geological formations of that district—Archæan, Cambrian, and Silurian—were disrupted and driven over each other. Thus masses of rock, not more than a few hundred feet thick, were piled up so as to appear multiplied tenfold. The youngest strata were doubled under the oldest, and large slices of the ancient Archæan gneiss were made to rest on the Silurian limestones.

Fortunately the strongly marked characters of the different members of the Silurian series, the striking contrast between them and the Cambrian sandstones and Archæan gneiss, and the manner in which all these rocks are now laid bare on coast cliffs and rugged hill-sides, have rendered possible the task of unravelling this labyrinthine structure. The large maps, on the scale of 6 inches to a mile, on which this structure has been worked out by the Geological Survey, are by far the most complicated which the Survey has yet produced; indeed, I am not aware that such mapping has ever before been attempted. [Some specimens of these maps were exhibited.]

On exposed rock-faces we see a thin group of strata repeated again and again by small reversed faults, the lower beds being made to rest on the higher till they occupy a great breadth of ground, and appear of considerable thickness. Further examination will generally show that they have been all pushed westwards, and that their truncated under ends rest upon a platform of undisturbed rock along which they have travelled. We may further observe them to be abruptly cut off at a higher level by a sharp line, on which perhaps stands another series of piled-up beds. This piling up and truncation of the rocks is followed by a still more gigantic displacement. Lower and lower portions of the geological series have been torn up and thrust westward until at last the Archæan platform has given way, and masses of it, many hundreds of feet in thickness and many miles in length, have been driven over the younger formations. The horizontal distance to which this removal has reached can sometimes be shown to have amounted to at least ten miles; perhaps it may have been sometimes even greater.

In studying this complicated system of dislocations we soon meet with evidence that the movements were not all effected at one time, but that on the contrary they took place at intervals, the earlier being disrupted by the later. The lines of maximum thrust override those of lesser size, and the most easterly of these lines passes successively across all the others till it rests directly on unmoved rocks. The period of terrestrial disturbance was probably a prolonged one, and this inference is strengthened by other evidence to be afterwards adduced.

The direction of movement has been on the whole from the east-south-east. Bordering the west coast of Sutherland and Ross there is a strip of ground about 10 or 15 miles broad and some 90 miles long, in which the rocks have not been displaced. East of that strip, along a belt of dislocation varying up to five or six miles in breadth, the disturbances become increasingly numerous and powerful towards the interior, until at last a gigantic thrust-plane is encountered, above and beyond which the rocks have been so crushed and altered, that it is for the most part no longer possible to tell what their original character has been. They are now flaggy schists—the younger "quartzose and gneissose flagstones" of Murchison, "the Moine schists" of the Geological Survey.

The enormous amount of fracturing, displacing, and crushing caused by these terrestrial disturbances has resulted in the development of regional metamorphism on an extensive scale. Every stage can be traced from a sandstone or conglomerate into a perfect schist, and from the most typical coarse Archæan gneiss into a fine laminated slate.

Where the feeblest amount of alteration has taken place, the rock has been merely somewhat crushed, its larger crystals or pebbles have been fractured, and the separated portions have been re-cemented. A further stage is shown where the fine material of the rock has been more comminuted and has been drawn out round the flattened and elongated crystals or pebbles. The latter give way in proportion to their power of resistance. The felspars and hornblendes are first left as "eyes," and then crushed down till they disappear in the general matrix. The harder quartz-pebbles of the conglomerates have resisted longer; but they too, in the planes of great movement, are found to be pulled out to twice or four times their length, or to be flattened out into mere thin plates like pennies. One of the most singular proofs of this internal movement of the component particles of even so obdurate a rock as quartzite is shown by the deformation of the worm-tubes. As these tubes come within the influence of the movement their vertical position changes into an inclined one, and they become gradually flatter and more drawn out, till at last, before they cease to be traceable, they appear as mere long ribbons on the surface of the rock, which then becomes a quartz-schist. Along the planes of intense crushing the original structure of a rock is entirely effaced, its crystals or grains are ground into fragments, and it acquires a streaked laminated structure like a shale or slate.

But for the most part, concomitant with the mechanical destruction of the various rocks, there has been a chemical and mineralogical re-arrangement of their particles. Out of their broken-down materials new minerals have crystallized, and this process of reconstruction has, in the most thoroughly altered masses, proceeded so far that the whole new structure is now crystalline. In this manner, mica, quartz, felspar, hornblende, and other minerals, have been developed, and have arranged themselves along the lines of movement in the crushed rock. These lines, approximating to the surfaces of the great thrust-planes, may be utterly discordant from the structure-lines, such as those of foliation or bedding, in the original mass. Rocks of this character are true schists, and I know of no internal or external signs by which, apart from field-evidence, they are to be distinguished from Archæan schists, as to the derivation of which we can only guess, and which, therefore, must in the meantime be considered as original rocks.

By the aid of the microscope, much assistance is obtained in tracing out the mineral transformations which have taken place in the course of this regional metamorphism. To show the larger features of the change, so far as they can be judged of in hand-specimens, I exhibit on the table a series of pieces of the crushed gneiss, quartzite, and conglomerate; and to illustrate the internal changes I show a selection of slides on the screen, photographed from thin slices of the rocks as seen under the microscope.

The importance of the discovery of this belt of extreme complication in the North-West Highlands can hardly be over-estimated. It gives us the key to the geological structure, not only of the Highlands, but of all the areas of younger crystalline schists in our own area, and will doubtless be found to explain much in the geological structure of Scandinavia. The lines of maximum thrust-planes can be followed for 100 miles, from the north of Sutherland into Skye; but this is only a small part of their extent. They can be picked up again in the west of Mayo and Donegal, a total distance of some 400 miles. That similar lines of movement have affected Scandinavia and produced the distinctive strike of the rocks there can hardly be doubted, so that the total length of disturbed country in North-Western Europe probably exceeds 1600 miles, trending in a general north-north east direction.

How far the influence of the great terrestrial movements extended eastwards from what now appears as the belt of maximum disturbance, and what effect it had upon the configuration of the surface, are questions to which as yet no satisfactory answer can be given. It is difficult to suppose that such colossal displacements and fractures of the crust should not have powerfully affected the superficial topography of the time. They may have produced a high mountain range, or a succession of parallel ranges, extending along the north-west of Europe. The existence of some such mass of land is needed to account for the vast piles of sediment of which the Palæozoic, Secondary, and Tertiary formations have been built up. So great, however, is the antiquity of these terrestrial movements, so continual and gigantic has been the denudation, and so repeated have been the oscillations of level, that the upheaved land has been reduced to the fragments that now form the Highlands and Islands of the west of Ireland, of Scotland, and of Scandinavia.

It is quite clear that during the disturbances in the north-west region the main thrust came from the eastward. It will be interesting to discover how far towards the east these disturbances affected the structure of the rocks beneath. That it reached across the whole breadth of the Scottish Highlands—that is, for a distance of 100 to 130 miles—can be conclusively proved. That it extended much further, and embraced within its area the whole of the Silurian regions of the three kingdoms can, I think, be shown to be highly probable.

To understand this part of the problem it is necessary to consider the structure of the ground immediately to the east of the belt of extreme complication in the North-West Highlands. I have said that the displacements and metamorphism increased in intensity from west to east, until at last, by a final gigantic thrust, a series of reconstructed schists has been driven over rocks whose origin can still be determined. Among these eastern schists it is occasionally possible to detect more or less reliable traces of the original rocks out of the crushing down of which they have been formed. Thus we find in the northern part of the area slices of Archæan and eruptive rocks, and in the south an increasing amount of material which has been derived from the destruction of the red Cambrian sandstones. It is tolerably evident that in the broad band of country which extends from the belt of complication eastwards to the Moray Firth and the line of the Great Glen, and embraces the mountainous tracts of Sutherland, Ross, Western Inverness-shire, and North-Western Argyllshire, the lower parts of the geological record are repeated again and again. It is mainly the Archæan platform, with its covering of Cambrian sandstones, and possibly the lower parts of the Silurian series, which have been broken up, plicated, crushed, and converted into the series of crystalline schists that form the picturesque heights of Ben Hope and Ben Klibric southward to the Moidart and Morven. Nevertheless, when this wild tract of country comes to be mapped out in detail, there will probably be found intercalated bands of higher formations which have here and there been caught in folds of the lower rocks.

But when we pass eastwards from the Great Glen into the mountains of Eastern Inverness-shire, Perthshire, and the South-Western Highlands, we encounter a totally different series of rocks. Though greatly plicated, dislocated, crushed, and metamorphosed, these rocks can be recognized as unquestionably, in the main, of sedimentary origin. They must be many thousands of feet in thickness, including among their members such rocks as conglomerate, pebbly grit, quartzite, black slate, andalusite slate, phyllite, mica-schist, fine flaggy gneiss, and limestone, together with intrusive sheets and bosses of various eruptive rocks. Some of the groups of this series can be followed and mapped for long distances with nearly as much ease as the members of a succession of unaltered Palæozoic or Secondary formations. There is a belt of limestone, for example, which has been traced by the Geological Survey almost continuously from the coast of Banffshire to the west of Argyllshire, through the very heart of the Highlands—a total distance of not much less than 200 miles. These limestones have for the most part become so thoroughly crystalline, that fossils can hardly be expected to be found in them, though there are occasional less altered portions of rock which may eventually prove to be fossiliferous. The limestones are associated with quartzites and schists, as unaltered limestones are with sandstones aud shales. I cannot myself doubt that they have been formed by the aggregation of the remains of calcareous organisms. The same rocks are prolonged into the north of Ireland, where one of the dark limestones at Culdaff has lately yielded certain bodies which some palæontologists have declared to be the remains of a coral (*Favosites*). The black slates which so closely resemble the dark Carbonaceous shales of the Lower Silurian region of South Scotland have afforded in Donegal some curious pyritous markings, strongly suggestive of Graptolites.

Out of this enormous mass of metamorphosed sedimentary strata the Scottish Highlands east of the Great Glen are built up, as well as the region which extends southwards across the north-west of Ireland as far as the centre of County Galway. The first question that requires an answer with regard to it has reference to its relation to the fossiliferous quartzites and limestones of the north-west. Murchison, who led the way in the investigation of the stratigraphy of the Highlands, believed that the quartzites and limestones of the Central Highlands lay towards the base of the whole series of post-Cambrian rocks, and were the south-eastward extensions of those of Sutherland. But recent investigations throw some doubt on this view, which at the time it was promulgated seemed so natural and simple. We know that the quartzites and limestones of the Central Highlands, so far from being near the bottom of the vast series of schists, are underlain by many thousand feet of other metamorphosed sedimentary strata, and that the actual base is nowhere reached in that region.

During the last two years, in concert with some of my colleagues of the Geological Survey, I have devoted some time to the task of endeavouring to find the bottom of these crystalline schists of Scotland and Ireland, as a necessary foundation for placing them on their true geological horizon, and at length, this spring, our efforts have been successful beyond our expectations. Last year, in the north-west of the Island of Islay, I found a group of scarcely altered shales, grits, and thin limestones emerging from beneath the black slates which underlie the schists, limestones, and quartzites of that region. So little have these strata suffered from the metamorphism which has affected the rocks lying above and to the east of them, that I quite anticipate that fossils will be found in them. This year, in company with Mr. C. T. Clough, I came upon a somewhat similar group of little-metamorphosed black slates and grits at the north-east end of the Island of Iona. I am hopeful that these strata will yield fossils; I myself found in them some short black limes, which at once recalled the form and condition of the fragments of the central rods of Graptolites so commonly met with in the black shales of the Southern Uplands of Scotland. The discovery of recognizable fossils in these strata would fix the geological age of the rocks of the Central Highlands and of the north-west of Ireland.

An interesting feature about these slates of Iona is that they lie at the very bottom of the series of younger schists. Immediately under them are a coarse grit (arkose) and conglomerate, formed out of the Archæan gneiss, which comes out in great force from underneath them, and forms the main part of the island.[1] The uprise of an axis of the old gneiss so far to the east of the line of great complication, and at the base of the vast sedimentary masses of the Central Highlands, is a fact of great importance. We seem to find here a fragment of the old barrier which separated the American province in which the Durness limestones were deposited, from the area of Western and Central Europe in which the other Silurian formations of Britain were laid down. Prolongations of the same ridge towards the north-east are possibly to be traced even as far as the mountains between the head of the Rivers Nairn and Findhorn, where some of my colleagues think that there is probably another core of the Archæan gneiss.

The search for a base to the same great series of schists as they are developed in the north-west of Ireland has been equally successful. Along the west of County Mayo, Archæan gneiss has been recognized by us,[2] exhibiting the typical characters of the same rock in the north-west of Scotland. In Achill Island we found the base of the quartzite and schist series in the form of a coarse quartz-conglomerate resting on the gneiss. But all these rocks have come within the influence of the intense regional metamorphism. The conglomerate in particular has had its quartz-pebbles pulled out in the direction of movement, and its paste has been converted into a fine kind of gneiss.

Having thus traced an original westward boundary to the younger crystalline schists of Ireland and Scotland, I saw that it would be important to follow their eastern boundary as far as it had not been concealed by later formations. In Galway we found that the quartzites, limestones, and schists are succeeded to the south by the large area of Archæan gneiss already referred to. But the boundary between the two groups of rock is one of extreme complication, somewhat like that of the North-West Highlands. Along a line running east and west through the heart of this county from Mannin Bay to Lough Corrib, the two groups have been so dislocated and so thrust between and over each other that much time and patience, with the use of large-scale maps, would be required to map out their respective areas. But the important fact is readily perceptible that in Galway the uprise of a large Archæan area gives us a southern limit for the basin in which the younger schists of the north-west of Ireland were deposited.

To the east and north-east of the Galway area the country has been overspread with Old Red Sandstone and Carboniferous strata, so that for a long space the older rocks are concealed. Far to the north-east, in Tyrone, on the southern borders of the great area of crystalline schists, a mass of dark hornblendic rocks was mapped some years ago by Mr. Nolan, of the Geological Survey of Ireland, and referred doubtfully to a pre-Cambrian age. A more recent examination of this mass, with the experience gained over so wide a region among the older crystalline rocks, has enabled us to identify it without hesitation as a characteristic portion of the Archæan gneiss. It rises as a long north-east ridge along the south-eastern margin of the chloritic schists of Londonderry which were deposited against and over it. We discovered, moreover, that these schists have at their base, resting on the old gneiss, a thick volcanic series consisting of amygdaloidal basic lavas, tuffs, and coarse volcanic agglomerates. The green chloritic material of the schists, not improbably represents the original magnesian silicates in the finer volcanic dust that mingled with the ordinary sediment of the sea-bottom.

From the evidence now adduced, it is, I think, manifest that the crystalline schists of the Scottish Highlands east of the Great Glen, as well as their continuation into the north-west of Ireland, cannot be regarded as merely the equivalents of the quartzites and limestones of Sutherland and Ross. They are enormously thicker and more varied in their component members than those north-western strata. Whether even any part of them represents the sedimentary rocks of the north-west seems to me open to serious doubt. My own impression is that they are probably younger than these rocks, and that they once stretched far to the north-west, and covered them to a depth of many thousands of feet. That the fossiliferous strata of the North-West Highlands were originally buried under a thick pile of other sediments I have already shown.

The last question on which I propose to touch is the geological date of the extraordinary terrestrial disturbances to which the crystalline schists of the Highlands of Scotland and the north-west of Ireland owe their characteristic structures. The limit of its antiquity is easily fixed. As these disturbances involve rocks containing fossils of Lower Silurian age, they must obviously have taken place after some part at least of the Lower Silurian period. In Scotland their chronological limit in the other direction is determined by the fact that the conglomerates of the Lower Old Red Sandstone are largely composed of the crystalline schists of the Highlands. They must consequently have occurred before the deposition of some part at least of the Lower Old Red Sandstone. Here, then, is a long geological interval within which the gigantic upthrusts and metamorphism began and ended.

But the evidence obtained in Ireland enables us to fill up this interval with a little more definiteness. In Southern Mayo and Northern Galway, as Prof. Hull has pointed out, the Upper Silurian rocks rest upon and contain abundant fragments of the younger crystalline schists which stretch into these counties from Donegal. And the inference has naturally been drawn that the great terrestrial disturbances and metamorphism occurred before the Upper Silurian period But a recent more critical examination of the ground has satisfied me that this inference, though to a certain extent correct, does not embrace the whole truth.

Those who have visited Connemara may remember the singular group of mountains which hem in the Killary fjords, and rise in Mweelrea and its neighbouring ridges to a height of more than 2600 feet above the sea that frets their base. These massive buttresses of rock owe their distinctive forms to the thick beds of coarse grit and conglomerate of which they are in great measure built up. An abundant series of fossils proves that this mass of deposits is of Upper Silurian age. It is the base of these exceedingly coarse sediments which along their southern margin can be seen to rest upon the upturned edges of the crystalline schists, and to be there largely made up of fragments derived from that metamorphic platform. The numerous bands of coarse conglomerate upon successive horizons serve to indicate considerable terrestrial disturbance during their deposition. That the commotion continued after that time is further shown by the remarkable way in which the rocks have been dislocated. These Upper Silurian sediments have been broken up into large mountainous blocks which have been thrown on end or actually pushed over each other. So violent

[1] The existence of a slight displacement at the actual junction does not obscure the evidence of the true relation of the rocks.

[2] In my recent traverses in the west of Ireland I had the advantage of the company and assistance of my colleagues, Mr. Peach, Mr. McHenry, and Dr. Hyland.

has the movement been along certain lines, that the bands of greywacke and shale have been intensely crumpled and puckered, and have actually been converted locally into fine micaceous schists.

Hence it seems tolerably certain that though in the west of Ireland the chief plications, fractures, and metamorphism were completed before Upper Silurian time, and though a vast interval must have elapsed during which the progress of denudation laid bare the younger schists, and thereby provided materials for the Upper Silurian conglomerates, the terrestrial disturbances nevertheless continued during the deposition of these conglomerates, and were renewed with increased vigour afterwards.

If we compare the geological structure of the Silurian tracts of England, Wales, and the south of Scotland, and the east of Ireland, with that of the areas of the younger crystalline schists, many points of resemblance will be seen to occur between them. Towards the north and north-west we find that the Archæan, Cambrian, and oldest Silurian rocks, now exposed there by the progess of denudation, have been subjected to the intensest mechanical deformation, and have assumed the most completely schistose structures. Coming southward, we trace the younger crystalline schists of the Central Highlands and of Donegal thrown into innumerable north-east and south-west folds, and becoming less and less metamorphosed as they are followed towards the lower grounds. Still further south the Lower and Upper Silurian rocks, plicated, crumpled, and dislocated, repeat the familiar structure of the Southern Highlands, but with only partial and feeble metamorphism. I am disposed to look upon the whole of these structures as the result of one great succession of terrestrial movements which began and reached their maximum of intensity during some part of Lower Silurian time, but which continued to repeat themselves at intervals with greater or less vigour through a long series of geological ages, down to the early part of the Old Red Sandstone period.

As the consequence of this prolonged disturbance, the Archæan and older Palæozoic rocks have been thrown into those north-east and south-west folds, which have in large part determined the trend of the land in the north-west of Europe. The shaping of our mountains into their present forms has been brought about by ages of subsequent sculpture, in which the agencies employed by Nature have operated mainly on the surface, but the carving of their features has been guided by the internal structures developed by those subterranean movements which we have been considering.

THE ENTIRE SKELETON OF AN ENGLISH DINOSAUR.

SOME years ago an article appeared in the columns of this journal (vol. xxviii. p. 439), in which a notice was given of the marvellously preserved skeletons of *Iguanodon* from the Wealden deposits of Bernissart, in Belgium, some of which are now exhibited in the Brussels Museum of Natural History. In that article the author very properly insisted upon the extreme importance of those specimens from an anatomical point of view, as exhibiting the whole of the bones of the skeleton in their natural juxtaposition. He was, however, probably then unaware (as the undermentioned specimen was not at that time exhibited to the public) that the British Museum possessed the skeleton of an English Dinosaur, which, although of smaller size than the Bernissart Iguanodons, belongs to the same sub-ordinal group, and exhibits equally clearly the mutual relations of the component bones. The English skeleton is, indeed, in some respects much more satisfactory than the Belgian specimens, inasmuch as its bones have not been flattened and crushed in the manner which so sadly disfigures those of the latter. Further, the English Dinosaur has an additional interest in that it is one of quite the earlier members of the group, its geological horizon being the Lower Lias of Dorsetshire.

This specimen, as being the only known example of the almost entire skeleton of a Dinosaur from English deposits, is so remarkable as to deserve especial attention from all those interested in the former inhabitants of our islands. In the first place, the history of its discovery is somewhat curious. Thus, some time previously to 1861, Mr. J. Harrison, of Charmouth, obtained from the Lower Lias of that neighbourhood portions of the hind-limb of a comparatively large Dinosaur, and, later on, a skull, lacking only the extremity of the muzzle. In the year mentioned, these specimens were described by Sir Richard Owen in the publications of the Palæontographical Society, under the name of *Scelidosaurus harrisoni*; the portions of the limb being taken as the type of the genus, and the skull referred to a smaller individual of the same species. Stimulated by the extreme interest aroused by the discovery of this skull, Mr. Harrison continued his excavations on the spot where the latter had been obtained, and was rewarded by finding the whole of the remainder of the skeleton, with the unfortunate exception of most of the vertebræ of the neck. The skeleton was extracted in several blocks, and these, after careful "development" of the bones, were fitted together so as to enable the whole skeleton to be exhibited.

Until the completion of the Natural History Museum at South Kensington, this magnificent skeleton was, however, from want of space, never exhibited to public view; and it was not until some three years ago that it was properly mounted and placed in its present position, where, in a handsome glass case which permits a view of both sides, it forms one of the chief treasures of the unrivalled gallery of fossil reptiles in that Museum. The bones being all firmly cemented together by matrix, and also more or less dislocated out of their normal places, it was, however, of course impossible to mount the skeleton in its natural position—which was probably a semi-erect one; and it is accordingly now placed with the axis of the vertebral column in a horizontal position. As thus mounted, the specimen is about 11 feet in length, but the absence of the cervical vertebræ renders it impossible to ascertain its true dimensions, the head being now placed much too near to the shoulder-girdle. The skeleton has been somewhat dislocated, and twisted over to the right side, so that the neural arches and spines of the vertebræ of the back and loins are seen on the right, and the under surface of their bodies, or centra, on the left side of the specimen. Both hind-limbs are entire, although the left one is thrust up by the twist, and has become placed near the tail. The haunch-bones (ilia) of the pelvis still nearly retain their normal position; and on the left side of the specimen we see the lower extremities of the left pubis and ischium lying crossed over the lower ends of the corresponding bones of the right side. A portion of that part of the pubis which lies in advance of the acetabulum is visible; and the post-acetabular portions of both the pubis and ischium lie in the original parallel position which is so characteristic of this group of Dinosaurs and of the Struthious birds. The left side of the shoulder-girdle is well preserved, and has the humerus and portions of the bones of the fore-arm in their original position; but the bones of the hands are wanting. The dermal scutes, with which the body and tail were protected, are seen arranged in longitudinal rows, which have, however, been somewhat thrown out from their original position. We would especially call the attention of those who may think it worth their while to visit the Museum, in order to study this unique specimen, to the marvellous preservation of the hind-limbs, which permits even the smallest bones of the toes to be fully exhibited on both sides. It may, however, be worth the consideration of the authorities of the Museum, whether this skeleton might not be more easily understood by the uninitiated if the various bones were labelled with their scientific, and perhaps also with their popular, names, since it is somewhat puzzling, even to the expert, to name them all at a glance.

As already mentioned, the skull of the skeleton was figured by Sir R. Owen in 1861, and the acquisition of the remainder of the skeleton enabled that eminent palæontologist to confirm his reference of the skull to the genus *Scelidosaurus*. The body-skeleton formed, indeed, the subject of a second memoir published by the Palæontographical Society in 1862, with eleven quarto plates; but we venture to say that these illustrations do not render justice to the specimen, since they only include separate portions. To fully illustrate this unrivalled skeleton would, indeed, require a double quarto plate, in which the whole specimen should be shown, with the individual bones duly labelled; and a task thus remains for some zealous palæontologist to fulfil.

The accompanying figure is an attempt at a restoration of the skeleton in the natural position of the animal. The presence of a predentary bone in advance of the mandibular symphysis is based on the occurrence of this element in *Iguanodon* and the allied *Stegosaurus;* while the five digits in the hand are likewise introduced from the evidence of the latter genus.

The importance of this specimen is that it is the only English Dinosaur, with the exception of the small *Hypsilophodon*, which shows all the bones of the skeleton in position; and although it is of course exceedingly easy to be wise after the event, yet we cannot help thinking that this skeleton might have afforded its describer the opportunity of being the first to determine the true nature and position of the bones of the pelvis in this group of Dinosaurs—a problem which was solved in a paper communicated to the Geological Society in 1876. The two parallel bones lying on the inferior aspect of the hinder part of the trunk of this specimen, and directed backwardly, could not, indeed, possibly have been taken for anything else but the pubis and ischium; and the resemblance of the latter bone to the problematical "*os cuvieri*," or so-called clavicle, of Mantell's imperfect skeleton of *Iguanodon*, which has for many years been in the Museum, might have suggested the homology of

Approximate restoration of the skeleton of *Scelidosaurus harrisoni*, from the Lower Lias of Charmouth. Greatly reduced. The vertebral column has been restored from *Iguanodon*, and the spines and chevrons of the vertebræ are, not improbably, too long: the ossified tendons are conjectural.

the two bones. Curiously enough, however, the pubis and ischium, which are certainly the most remarkable bones in the whole skeleton, are not figured, and apparently not even mentioned, in the original memoir.

Finally, it may perhaps interest some of our readers who do not follow the ever-changing classifications of the palæontologists, to mention that the genus *Scelidosaurus* is the type of a family referred by Prof. O. C. Marsh to his sub-order Stegosauria. Other authorities, however, consider that this sub-order is not really separable from the Ornithopoda of the same writer, which includes the Iguanodons. Accepting this emendation, the Ornithopoda will be a sub-order of Dinosauria, including all those forms in which the pelvis has a structure comparable to that of the Struthious birds; while the remaining members of that order may be classed in the sub-order Theropoda, as represented by *Megalosaurus*, and the Sauropoda, as represented by *Cetiosaurus* and *Pelorosaurus*. Recently, indeed, it has been proposed to abolish the name Dinosauria, and to group the Theropoda and Sauropoda together under the new name of Saurischia, and to apply the name Ornithischia to the Ornithopoda. The name Dinosauria has, however, become such a household word, that its suppression cannot be admitted; and if it be eventually found advisable to adopt the proposed division of these reptiles into two distinct orders, the preferable course would be to restrict the name Dinosauria to the so-called Saurischia, since *Megalosaurus* and *Cetiosaurus* were the forms first mentioned in the original notice of the order in 1840; while the earlier names, such as Ornithopoda, might be retained for the second order. In this connection we may, however, quote a remark made by an eminent man of science at a meeting of the Geological Society, to the effect that "he was inclined to think that the progress of knowledge tended rather to break down the lines of demarcation between groups supposed to be distinct, than to authorize the creation of fresh divisions."

R. L.

NOTES.

We print elsewhere the Technical Instruction Bill introduced into the House of Commons last week by Sir W. Hart Dyke. The Government is to be congratulated on having presented a measure which cannot fail to produce an excellent effect on the higher branches of technical education in England.

WE regret to have to announce the death of the Rev. J. M. Berkeley, the eminent cryptogamic botanist.

THE Professorship of Civil Engineering and Mechanics in the University of Glasgow is likely to be vacant by the resignation of Prof. James Thomson, on account of weak health. The appointment, which is supposed to be worth about £600 a year, is in the gift of the Crown.

THE eleventh Congress of the Sanitary Institute, which is to meet at Worcester from September 24 to 28, will be divided into three Sections, viz. Section I. Sanitary Science and Preventive Medicine; Section II. Engineering and Architecture; Section III. Chemistry, Meteorology, and Geology. Each Section will begin its work on a separate day. A Conference of Medical Officers of Health will be held during the Congress; and there will be a Health Exhibition in the Skating Rink and special additional buildings from September 24 to October 19. This Exhibition will include sanitary apparatus and appliances, and articles for domestic use and economy.

THE International Congress on Hygiene, which is to meet in Paris on Sunday, will be attended by nearly 600 members, representing twenty-five nationalities. The Paris Correspondent of the *Times* says that the members will be lavishly entertained at the Ministry of Public Instruction, at the Ministry of the Interior, at the Hôtel de Ville, and by the town of Rheims, where they will visit the important works for the treatment of sewage. Several European Governments will be officially represented, notably Belgium, Denmark, Spain, and Turkey. Brazil and nearly all the South American Republics send official delegates. Prof. Corfield, Mr. Shirley Murphy, Dr. Alfred Carpenter, and some other Englishmen interested in sanitary questions, propose to attend the meetings.

THE International Congress of Photography will meet in Paris from August 6 to 17. The rules relating to the proceedings of the Congress have been issued.

THE eighth Congress of Russian Naturalists will be opened at St. Petersburg on January 7, 1890, and will last a week.

THE Russian Chemical and Physical Society, as we learn from its Annual Report, has now 340 members. Its Journal contains every year a most valuable index of all that is published in Russia in the domain of chemistry and chemical technology.

THE monument erected by the Russian Consul at Kashgar, in memory of Adolph Schlagintweit, is reported to be ready. It is in the form of a pyramid with an iron cross on the top, and has been erected on the very place where the great German traveller was executed by order of the then ruler of Kashgar, Vali-khan-tyuria.

ON Thursday last, the new galleries and the new greenhouse of the Museum of Natural History of Paris were formally opened by the Minister of Public Instruction, who was accompanied by the Director, Prof. Frémy, and, among others, by M. de Quatrefages, M. Gaudry, M. Chauveau, and M. E. Blanchard. The new gallery is a fine building, three stories high, built of iron and stone. The collections have already been in part transferred to it. The greenhouse is a very ordinary one. Enormous substructures have been rendered necessary by the fact that it is on the side of a small hill. The building was begun ten years ago, and serves to show what progress has since been made in the art of iron-building.

ACCORDING to the Rome Correspondent of the *Daily News*, the Municipal Council of Rome has decided to devote a sum of money to the formation of a Pasteur Institute. Confidence in M. Pasteur's treatment of hydrophobia is increasing in Italy, as is shown by the fact that little by little all the principal towns are providing buildings for the treatment of the disease by inoculation.

ADMIRAL SIR ROBERT SPENCER ROBINSON, K.C.B., F.R.S., died at his residence, 61 Eaton Place, on July 27, in his eighty-first year. He was elected a Fellow of the Royal Society in 1869. Among his works was a treatise on the steam-engine for marine purposes.

MR. W. F. H. BLANDFORD succeeds Mr. A. E. Shipley, who has resigned the post of Lecturer on Economic Entomology at the Royal Indian Engineering College, Cooper's Hill.

AT the session of the Council of University College, London, on July 6, the title of Emeritus Professor of Engineering and Mechanical Technology was conferred on Prof. A. B. W. Kennedy, F.R.S.

THE Association for the Improvement of Geometrical Teaching has begun the formation of a library of reference of mathematical text-books. This should increase the usefulness of the Association to teachers of mathematics, especially to such as live in the neighbourhood of London. The library already contains a respectable assortment of works, contributed by various authors and publishers. It is, of course, intended chiefly for works of recent date, but it contains a loan collection of older works, lent by Mr. F. Hockliffe, of Bedford, among which may be mentioned Cocker's "Arithmetic," Tacquet's "Elementa Geometriæ," and D'Chales' "Elements of Euclid," The library is at present under the charge of Mr. C. V. Coates (2 Prince's Mansions, Victoria Street), who will be glad to receive donations of books, pamphlets, &c., on behalf of the Association.

IN the Report submitted to the general meeting of the Scottish Meteorological Society on June 24, the Council state that the preparation of No. VI. of the Society's Journal has been kept steadily in progress, and is now in type, and will shortly be issued to members. In this number a fuller account is given than heretofore of the storms which strike the Scottish coasts, drawn chiefly from the very full and accurate reports of storms from the northern lighthouses. These reports of storms may justly be regarded as the fullest accounts of storms made anywhere in the world by observers who record the phenomena night and day. The Council are of opinion that it is not possible to overrate the importance of these observations of storms in their bearing on the discussion of the Ben Nevis observations and the weather of North-Western Europe, which, it is proposed, will engage the whole time next year of the Secretary and such assistance as may be obtained. The photographing of meteorological phenomena continues in progress as opportunity offers, and at the next meeting of the Society the directors will be in a position to show to members a second series of these interesting and important photographs. This year the snow disappeared from the summit of Ben Nevis in the middle of May, being about a month earlier than any previous year, and seven weeks earlier than in 1885. Shortly thereafter, or in the beginning of June, the spring near the Observatory dried up; and during that month the water supply for the Observatory had to be carried on horseback, from a distance of two miles and a half. The directors have had under consideration a proposed systematic observation of the numbers of dust particles in the atmosphere with the instrument recently invented by Mr. Aitken, one of the directors, and they are of opinion that, for many reasons, the best place for most satisfactorily conducting the observations is the Ben Nevis Observatory. Mr. Aitken has kindly agreed to superintend the construction of the instrument, and to see to the placing of it in a suitable position. It has been resolved to apply for a grant from the Government Research Fund to aid in this novel and important inquiry. M. Mascart, Director of the Meteorological Service of France, has also resolved to carry on the same investigation in Paris.

IN a telegram from Yokohama, dated July 30, it is stated that the town of Kumamoto, on the Island of Kiou-Siou, near Nagasaki, had been visited by an earthquake, causing great loss of life and destruction of property.

SOME details with regard to the recent severe earthquake in Turkestan have been received at St. Petersburg. The first shock was felt at Vyernyi at 3.15 a.m. on July 12. Several houses were damaged and a great number of chimneys were destroyed. The same shock was felt at Jarkend, Pishpek, Ala-medyn, Prjevalsk (Kopal), Pavlodar, Lepsa, Semipalatinsk, Kulja, and on the Kashgar frontier. At Prjevalsk, all private houses on the shores of Lake Issyk-kul, as also the bridges, were destroyed; the shores bear many traces of landslips. The shock was so severe that people could hardly stand on their feet. At Pavlodar the direction of the earthquake was from south-west to north-east. At Semipalatinsk, the Irtysh was covered with heavy waves. The whole of the village Malovodnoie was destroyed, and in the canton of Koram seventeen men were killed. Several houses were destroyed in the villages of Zaitsevskoie, Mikhailovskoie, Lugovoie, Janghyz, and Karabulak, as also at Kulja. On July 14, three shocks were noticed at Jarkend, at 2, 4, and 10 p.m., and they were followed by several feebler shocks on July 15.

THE master of the *Argentina*, German mail steamer, which arrived at Lisbon from Pernambuco on July 19, reports that north of the Cape de Verd Islands heavy cross seas were experienced, in which the vessel pitched heavily. For four days the air was filled with reddish yellow dust, sometimes so thick that the sun could scarcely shine through it, and looked quite pale, although the sky was cloudless.

AMONG donations received at the meeting of the Royal Botanic Society on Saturday were seeds from the Parana River at Rosario, South America, collected by Mr. C. W. Sowerby. Mr. Sowerby announces his discovery of one of the habitats of *Pontedera azurea*, a very beautiful floating water-plant, which flowered some nine years ago in the Victoria House in the Society's Gardens, and has since been widely distributed. He states that masses of the plant were found floating down the river, and forming islands of one or two acres in extent, upon one of which a puma was seen.

AT the monthly meeting of the Royal Society of Queensland, on June 14, Mr. De Vis read a most interesting paper on *Prionodura newtoniana* (Meston's bower-bird) and *Acanthiza squamata*, recent additions to the Queensland avifauna. The former was minutely described. It was first found by Mr. K. Broadbent in the scrubs on the Tully River, but its true habitat is now ascertained to be the highlands north of Herberton, where it was observed by Mr. A. Meston in the course of a short visit to the top of Bellenden-Ker. Mr. Meston brought down the first skin of a male bird, but not in a condition to permit full recognition. Excellent specimens, male and female, were afterwards obtained by Mr. Broadbent near Herberton. Prionodura is emphatically a bower-bird. Both its observers in nature met with its bowers repeatedly, and agree in representing them as of unusual size and structure. The bower is usually built on the ground between two trees, or between a tree and a bush. It is constructed of small sticks and twigs, piled up almost horizontally round one of the trees, and rising to a height of from 4 to 6 feet. A similar pile about 18 inches high is then built round the foot of the other tree; the intervening space is arched over with stems of climbing plants; the piles are decorated with white moss, and the arch with moss interspersed with bunches of fruit resembling wild grapes. The birds, young and old, male and female, play merrily under and over the archway. The completion of the massive bower so laboriously attained is not sufficient to satisfy the architectural impulse of the bird, for scattered immediately around are numbers of dwarf hut-like structures—gunyahs they are called by Mr. Broadbent, who remarks that they give the spot exactly the appearance of a blacks' camp in miniature.

THE current number (vol. iii. No. 4) of the Journal of the Bombay Natural History Society contains a paper by Lieut. Barnes, on nesting in Western India, a district which, so far, appears to have been treated in an incomplete fashion in works on Indian oology. The writer seeks to collect, in as concise a form as possible, all information at present available on the subject, as a nucleus round which collectors may record their observations, and thus prepare the way for a complete knowledge of bird-life in Western India. Dr. Dymock writes on the means of self-protection possessed by certain plants, and Mr. Hart on certain branching palms, while Mr. Aitken discourses pleasantly on the natural history of a voyage from Liverpool to Bombay, and Mr. Oates has a short paper on the Indian and Burmese scorpions of the genus Isometrus, with a description of three new species. The Journal is almost always sure to contain one or two papers, half scientific, half sporting, from the pens of noted *shikarees*, which are sometimes of vivid interest. The present issue has a paper of this class on the habits of the sambhur, with personal reminiscences of sport in pursuit of it, by Mr. Reginald Gilbert, and a striking anonymous paper entitled "Mauled by a Panther." The illustrations, as usual, are numerous and of great beauty.

WITH regard to the question of the inheritance of injuries, a correspondent, "P. V.," writes to us about an Irish terrier bitch which had a litter by a mongrel terrier whose tail had been cut off with a hatchet. Of the litter, one dog puppy was without a tail. The Irish terrier belonged to "P. V.," and he says that she had had several litters before, none of which were in any way deformed.

PROF. FRANZ KLAPÁLEK, of Prague, has been investigating the rivers of Bohemia under the auspices of a committee formed for their physical exploration. In the course of his researches he was able to study the full life-history of *Agriotypus armatus*, Walker, a curious hymenopterous parasite on the aquatic larvæ of caddis-flies, chiefly of the genus *Silo*. The details are published in the *Entomologist's Monthly Magazine* for August, with illustrations. When these larvæ are attacked by the parasite, the cases have always a curious band-like appendage at one end. Formerly it was considered that this appendage was formed by the caddis-worm, but Prof. Klapálek proves that it is due to the larva of the parasite, and consists of the secretion from the salivary glands. What its precise use may be does not at present seem quite clear.

PROF. W. K. BURTON, of the College of Engineering, Imperial University, Tokio, writes to the *Japan Mail* that the Photographic Society of Japan has now been duly constituted, and that there are already nearly sixty members, of whom very nearly one-half are Japanese. There are a few professional photographers, but the great majority are amateurs. Viscount Enomoto, Minister of Education for Japan, has consented to be nominated as President. A meeting of the Society was held on June 7, when Mr. K. Ogawa gave a demonstration of the working of the platinotype printing process of Willis, from the coating of the paper to the completion of the print.

THE last monthly part of Mr. Samuel H. Scudder's "Butterflies of the Eastern United States and Canada, with especial reference to New England," will be issued on October 1. We have already called attention to the importance of this work. It makes three volumes, and contains seventeen plates of butterflies, six of eggs, eleven of caterpillars, two of the nests of caterpillars, three of chrysalids, two of parasites, thirty-three of structural details in all stages of life, nineteen maps and groups of maps to illustrate the geographical distribution of butterflies, and three portraits of early naturalists of America; in all about 2000 figures on ninety-six plates, of which forty-one are coloured. The text contains 2000 pages, including an introduction of 104 pages, and an appendix, of 150 pages, which contains descriptions of such species concerned as have not been found within the limits of New England, and also descriptions of all known parasites of North American butterflies, by Messrs. Howard and Williston.

THE City of London College Science Society has issued its Report for 1888–89. We are glad to see that the session was one of increased activity, and, as the Committee are able to add, of continued success. Papers on subjects of great scientific interest were read, and there were many excursions to places suitable for geological study and for the collection of botanical and zoological specimens. The Society now publishes a monthly journal.

MR. PERCY LINDLEY is editing a series of "Holiday Handbooks." One of those sent to us deals with the Hartz Mountains, another with the Ardennes. They cost only a penny each, and are well done. For the same price one may now get a very good little illustrated Guide to London. It is published by Mr. J. P. Murray.

THE tenth part of Cassell's "New Popular Educator" has been issued. It is well illustrated, and has a good map of British North America.

A REMARKABLE series of experiments illustrating an extreme case of "mass" or "catalytic" action are described by Messrs. Morse and White of the University of Pennsylvania, Philadelphia, in the current number of the *American Chemical Journal* (p. 348). The sulphides and oxides of zinc and cadmium, which are so difficultly volatilizable when heated alone, are found to be readily volatilizable in presence of their respective metals, zinc or cadmium, owing to alternate dissociation and recombination. The pure sulphides were first prepared by dissolving redistilled zinc or cadmium in hydrochloric acid and precipitating with sulphuretted hydrogen. The washed pr cipitates were next dried in the ordinary way, and then heated to 300° C. in a current of pure dry sulphuretted hydrogen. They were finally repeatedly treated with carbon bisulphide to remove any traces of free sulphur. The sulphides as thus prepared were found to be perfectly stable in a vacuum, the exhausted tubes containing them being heated until the glass softened and collapsed without any signs of volatility of the sulphides being apparent. About 15 grams of either of the sulphides were then mixed with 40 grams of the corresponding metal and placed at the sealed end of a combustion tube, the other end being connected with a Sprengel pump. The end containing the mixture was placed in a furnace, and after the exhaustion was completed as far as possible, was gradually heated. As the temperature rose the metal began to fuse, and a yellowish white film of sulphur was formed in the cool portion of the tube projecting out of the furnace. The formation of this deposit is due to the fact that while the tube is comparatively free from the metallic vapour, the sulphur liberated by the dissociation of the sulphide, having a higher rate of diffusion than the vapour of the metal, partly escapes recombination, and is deposited in the free state in the cooler portion of the tube just outside the furnace. As the temperature still rises this deposit becomes converted into sulphide, and eventually a long line of crystals of the sulphide is formed along the bottom of the projecting part of the tube. Cadmium sulphide was found to be transported much further along the tube than zinc sulphide, and the crystals could be seen to form and fall in a manner resembling a fine rain. Indeed, so ready is the dissociation of cadmium sulphide under the influence of metallic cadmium that by rapidly raising the temperature the experiment becomes dangerous, the dissociation occurring with almost explosive violence. On several occasions when the mixture was too tightly packed into the end of the tube, the whole contents were violently blown into the Sprengel pump. It is necessary to leave a very considerable free space along the top of the tube to insure a successful experiment. It was found that the oxides of zinc and cadmium behave similarly to the sulphides, oxide of zinc in this case dissociating most readily. The singular action of these metals in lessening the stability of their respective oxides and sulphides certainly forms one of the most extreme cases of "mass" or "catalytic" action on record; and that it is not a mere mechanical carrying action appears abundantly proved by the slight deposit of sulphur which is always noticed in the earlier stage of the experiment, and by the beautiful manner in which the sulphides themselves are afterwards deposited.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♂) from India, presented by Mr. F. Dobbs; a Common Otter *Lutra vulgaris*) from North Wales, presented by Mr. Chas. H. Wynn; two White Storks (*Ciconia alba*) from North Africa, presented by Mr. Thomas Hay; three Well-marked Tortoises *Homopus signatus* ♂ ♀ ♀), four Rufescent Snakes (*Leptodira rufescens*), a Many-spotted Snake (*Psammophylax multimaculatus*), a Spotted Slowworm (*Acontias meleagris*), a Puff-Adder (*Vipera arietans*) from South Africa, presented by the Rev. G. H. R. Fisk; a Tesselated Snake (*Tropidonotus tessellatus*) from Italy, presented by Mr. H. D. Brocklehurst; two Common Toads (*Bufo vulgaris*), British, presented by Dr. J. J. Pitcairn; a Common Zebra (*Equus zebra* ♀) from South Africa, two Black-eared Marmosets (*Hapale penicillata*) from South-East Brazil, a Tovi Parrakeet (*Brotogerys tovi*) from Columbia, a Red and Blue Macaw (*Ara macao*) from Central America, deposited; a Peba Armadillo (*Tatasua peba*), a Pretre's Amazon (*Chrysotis pretrii*), a —— Snake (*Helicops leopardinus*) from Brazil, a White-throated Capuchin (*Cebus hypoleucus* ♂) from Central America, a Senegal Touracou (*Corythaix persa*) from West Africa, six Spotted Tinamous (*Nothura maculosa*) from Buenos Ayres, a Tesselated Snake (*Tropidonotus tessellatus*) from Italy, purchased; two Mule Deer (*Cariacus macrotis*), two Crested Pigeons (*Ocyphaps lophotes*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

DISCOVERY OF A NEW COMET, 1889 *e*.—A telegram from Melbourne to Prof. Krueger announces the discovery of a bright comet by Mr. Davidson, of Queensland, on July 21. The following positions of this comet have been obtained:—

Place.	G.M.T. (h. m. s.)	R.A. (h. m. s.)	N.P.D. (° ′ ″)
Melbourne ...	July 22 23 3 50 ...	12 46 9·0 ...	122 29 6
Rome	July 27 8 37 4 ...	13 37 29·9 ...	110 19 2

The comet is therefore coming north very rapidly.

COMET 1889 *d* (BROOKS).—The following elements and ephemeris for this comet are by Dr. H. Oppenheim:—

$$T = 1889 \text{ August } 3{\cdot}40 \text{ G.M.T.}$$

$$\left.\begin{aligned}\pi &= 339^\circ\ 37' \\ \Omega &= 28\ 13 \\ \iota &= 5\ 56\end{aligned}\right\}\text{Mean Eq. } 1889{\cdot}0.$$
$$q = 0{\cdot}3627$$

The comet probably has a short period.

Ephemeris for Greenwich Midnight.

1889.	R.A. h. m.	Decl. ° ′	Brightness.
July 31 ...	0 4·2 ...	7 3 S. ...	1·3
Aug. 4 ...	0 6·1 ...	6 48	
8 ...	0 7·7 ...	6 35 S. ...	1·4

The brightness at discovery is taken as unity.

COMETS 1888 *e* (BARNARD, SEPTEMBER 2) AND 1889 *b* (BARNARD, MARCH 31).—The following ephemerides are in continuation of those given in NATURE, 1889 July 11, p. 255 :—

1889.	Comet 1888 *e*. R.A. h. m. s.	Decl. ° ′	Comet 1889 *b*. R.A. h. m. s.	Decl. ° ′
Aug. 2 ...	19 49 27 ...	3 46·3 S.	5 3 35 ...	9 23·3 N.
6 ...	37 3 ...	4 28·0	5 1 36 ...	8 50·4
10 ...	25 34 ...	5 7·8	4 59 14 ...	8 14·5
14 ...	15 3 ...	5 45·7	4 56 23 ...	7 35·4
18 ...	5 34 ...	6 21·5	4 53 0 ...	6 52·8
22 ...	18 57 4 ...	6 54·9	4 49 2 ...	6 6·1
26 ...	49 32 ...	7 26·0	4 44 24 ...	5 15·2
30 ...	42 54 ...	7 54·9 S.	4 39 4 ...	4 19·6 N.

THE VIENNA OBSERVATORY.—We have received two volumes of the publications of this Observatory, viz. the Annals for 1885 and 1886 (*Annalen der k. k. Univ. Sternwarte in Wien, Währing*, Band v. and vi.). The former contains three sections, viz. (1) observations with the meridian circle in 1884, being Zones 119 to 198 of the observations of Santini's stars south of the equator; (2) corrections and notes to sundry catalogues, particularly to Oeltzen's catalogues of Argelander's zones and to the zone catalogues of Lamont and of the Washington Observatory; and (3) measures of double-stars made by Drs. Holetschek and Hepperger. The latter volume contains observations of minor planets and comets made with the Clark 11¾-inch refractor, the Fraunhofer 6-inch, and the great Grubb telescope of 27-inch aperture, and meteorological observations made in the years 1885 and 1886. There is an apparently unobserved erratum on p. 115 of the former section. The observation on 1885 October 3, said to be of Klymene (No. 104) is really of Ilsa (No. 249). It is given correctly under the latter planet.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *AUGUST* 4–10.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 4

Sun rises, 4h. 31m. ; souths, 12h. 5m. 50·1s. ; daily decrease of southing, 5·6s. ; sets, 19h. 41m. : right asc. on meridian, 8h. 58·8m. ; decl. 17° 8′ N. Sidereal Time at Sunset, 16h. 35m.

Moon (at First Quarter August 4, 13h.) rises, 12h. 50m. ; souths, 18h. 1m. ; sets, 23h. 1m. : right asc. on meridian, 14h. 55·1m. ; decl. 12° 8′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian h. m.	Declination on meridian ° ′
Mercury..	4 2 ...	11 53 ...	19 44 ...	8 45·6 ...	19 41 N.
Venus.....	1 0 ...	9 0 ...	17 0 ...	5 52·3 ...	21 0 N.
Mars......	3 6 ...	11 9 ...	19 12 ...	8 2·4 ...	21 31 N.
Jupiter....	17 8 ...	21 1 ...	0 54*...	17 56·0 ...	23 23 S.
Saturn....	5 23 ...	12 47 ...	20 11 ...	9 40·2 ...	15 10 N.
Uranus...	10 47 ...	16 16 ...	21 45 ...	13 9·4 ...	6 44 S.
Neptune..	23 29*...	7 18 ..	15 7 ...	4 10·3 ...	19 24 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Aug.	h.	
7 ...	— ...	Occultation of the planet Jupiter by the Moon. Disap. at 19h. 4m. Reap. at 20h. 1m. Angles from vertex to right for inverted image 25° and 290° respectively. The Sun sets at 19h. 35m.
7 ...	20 ...	Mercury in superior conjunction with the Sun.
7 ...	20 ...	Jupiter in conjunction with and 1° 6′ south of the Moon.

Meteor-Showers.

	R.A. °	Decl. °	
The *Perseids*	44 ...	56 N. ...	Max. August 10.
Near 41 Arietis	44 ...	25 N. ...	Swift ; streaks.
From Camelopardus ...	95 ...	70 N. ...	Slow.
Near ι Cygni	290 ...	52 N. ...	Slow.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.
Algol	3 1·0 ...	40 32 N. ...	Aug.	4, 22 39 *m*
δ Libræ	14 55·1 ...	8 5 S. ...	,,	8, 2 6 *m*
U Coronæ	15 13·7 ...	32 3 N. ...	,,	9, 22 3 *m*
U Ophiuchi... ...	17 10·9 ...	1 20 N. ...	,,	8, 0 49 *m*
X Sagittarii... ...	17 40·6 ..	27 47 S. ...	,,	5, 0 0 *M*
W Sagittarii ...	17 57·9 ...	29 35 S. ...	,,	7, 23 0 *m*
Y Sagittarii... ...	18 14·9 ...	18 55 S. ...	,,	5, 0 0 *M*
			,,	8, 23 0 *m*
β Lyræ...	18 46·0 ...	33 14 N. ...	,,	6, 21 30 *M*
			,,	10, 3 0 m_2
U Aquilæ	19 23·4 ...	7 16 S. ...	,,	7, 23 0 *m*
S Vulpeculæ ...	19 43·9 ...	27 1 N. ...	,,	4, *M*
η Aquilæ	19 46·8 ...	0 43 N. ...	,,	7, 23 0 *m*
S Sagittæ	19 51·0 ...	16 20 N. ...	,,	4, 3 0 *m*
			,,	7, 3 0 *M*
δ Cephei	22 25·1 ...	57 51 N. ...	,,	8, 3 0 *m*

M signifies maximum ; *m* minimum ; m_2 secondary minimum.

THE NEWCASTLE MEETING OF THE BRITISH ASSOCIATION.

ACTIVE preparations are now being made for the Newcastle meeting of the British Association, and it is expected that the proceedings will be of more than usual interest. The meeting will be held from September 11 to 19. At the first general meeting, on September 11, at 8 p.m., Sir F. Bramwell, F.R.S., will resign the chair, and Prof. Flower, C.B., F.R.S., the President-elect, will assume the presidency, and deliver an address. The different Sections will assemble on the following morning for the reading and discussion of reports and other communications. The following are the Presidents of the Sections:—(A) Mathematical and Physical Science, Captain W. de W. Abney, R.E., C.B., F.R.S.; (B) Chemical Science, Sir I. Lowthian Bell, F.R.S.; (C) Geology, Prof. James Geikie, F.R.S.; (D) Biology, Prof. J. S. Burdon-Sanderson, F.R.S.; (E) Geography, Col. Sir F. De Winton, K.C.M.G.; (F) Economic Science and Statistics, Prof. F. Y. Edgeworth, M.A.; (G) Mechanical Science, Mr. William Anderson, M.Inst.C.E.; (H) Anthropology, Prof. Sir W. Turner, F.R.S.

On Thursday evening, September 12, there will be a *soirée*; on Friday evening, September 13, Prof. W. C. Roberts-Austen, F.R.S., will deliver a discourse on "The Hardening and Tempering of Steel"; on Saturday evening, September 14, Mr. B. Baker will deliver a discourse on "The Forth Bridge"; on Monday evening, September 16, Mr. Walter Gardiner will deliver a discourse on "How Plants Maintain Themselves in the Struggle for Existence"; on Tuesday evening, September 17, there will be a *soirée*; and the concluding meeting will be held on the afternoon of Wednesday, September 18.

Excursions to places of interest in the neighbourhood of Newcastle-on-Tyne will be made on the afternoon of Saturday, September 14, and on Thursday, September 19.

The first meeting of the General Committee will be held on Wednesday, September 11, at 1 p.m., for the election of the President and Sectional officers, and the despatch of business usually brought before that body. The General Committee will meet again on Monday, September 16, at 3 p.m., for the purpose of appointing officers for 1890, and of deciding on the place of meeting in 1891. The concluding meeting of this Committee will be held on Wednesday, September 18, at 1 p.m., when the Report of the Committee of Recommendations will be received. The Committee of Recommendations will meet at 3 p.m. on September 16 and 17, and (if necessary) on September 18, at 10 a.m.

The Local Secretaries for the Newcastle meeting are Prof. P. Phillips Bedson and Prof. J. H. Merivale.

The Reception Room will be opened on Monday, September 9, at 1 p.m., and on the following days at 8 a.m., for the issue of tickets to Members, Associates, and ladies, and for supplying lists and prices of lodgings, and other information, to strangers on their arrival. No tickets will be issued after 6 p.m. In the Reception Room there will be offices for supplying information regarding the proceedings of the meeting. The Journal, containing announcements of the arrangements for each day, will be laid on the table on Wednesday, September 11, and the following mornings, at 8 a.m., for gratuitous distribution. Lists of members present will be issued as soon as possible after the commencement of the meeting, and will be placed in the same room for distribution. The published volumes of the British Association can be ordered in this room, for Members and Associates only, at the reduced prices appointed by the Council. The tickets will contain a map of Newcastle-upon-Tyne, and particulars as to the rooms appointed for Sectional and other meetings. For the convenience of Members and Associates, a branch post office (which will be available also for communication between Members attending the meeting) will be opened in the Reception Room. Members and Associates may obtain information about local arrangements, and facilities afforded by the railway companies, on application to the Local Secretaries, Newcastle-upon-Tyne.

THE GOVERNMENT'S TECHNICAL INSTRUCTION BILL.

THE following is the Bill to Facilitate the Provision of Technical Instruction, introduced into the House of Commons by Sir W. Hart Dyke, and read a first time, on July 24:—

Be it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

I. (1) A local authority may from time to time out of the local rate supply or aid the supply of technical or manual instruction, to such extent and on such terms as the authority think expedient, subject to the following restrictions, namely:—

(*a*) The local authority shall not out of the local rate supply or aid the supply of technical or manual instruction at an elementary school to scholars receiving instruction in the obligatory or standard subjects prescribed by the minutes of the Education Department for the time being in force; and

(*b*) The amount of the rate to be raised in any one year by a local authority for the purposes of this Act shall not exceed the sum of *one penny* in the pound.

(2) A local authority may, for the purposes of this Act, appoint a Committee consisting either wholly or partly of members of the local authority, and may delegate to any such Committee any powers exercisable by the authority under this Act, except the power of raising a rate or borrowing money.

II. (1) The managers of any school or other institution giving technical instruction in the district of a local authority may make an arrangement with the authority for transferring their school or institution to it, and the local authority may assent to any such arrangement.

(2) The provisions of Section 23 of the Elementary Education Act, 1870, with respect to arrangements for the transfers of schools, shall apply in the case of arrangements for the tranfers of schools or institutions in pursuance of this section, with this modification, that for the purposes of transfers to a local authority references to the School Board shall be construed as references to the local authority, and references to the Education Department as references to the Department of Science and Art.

III. The conditions on which Parliamentary grants may be made in aid of technical or manual instruction shall be those contained in the minutes of the Department of Science and Art in force for the time being.

IV. (1) For the purposes of this Act the expression "local authority" shall mean the Council of any county or borough, and any urban or rural sanitary authority within the meaning of the Public Health Acts.

(2) The local rate for the purposes of this Act shall be—

(*a*) In the case of a County Council, the county fund;

(*b*) In the case of a Borough Council, the borough fund or borough rate;

(*c*) In the case of an urban sanitary authority not being a Borough Council, the district fund and general district rate, or other fund or rate applicable to the general purposes of the Public Health Acts;

(*d*) In the case of a rural sanitary authority, the rate or rates out of which special expenses incurred in respect of any contributory place or places are payable under the Public Health Act, 1875.

(3) A County Council may charge any expenses incurred by them under this Act on any part of their county.

(4) A rural sanitary authority may charge any expenses incurred by them under this Act on any contributory place or places within their district.

(5) A local authority may borrow for the purposes of this Act—

(*a*) In the case of a County Council, in manner provided by the Local Government Act, 1888;

(*b*) In the case of a Borough Council, as if the purposes of this Act were purposes for which they are authorized by Section 106 of the Municipal Corporations Act, 1882, to borrow;

(*c*) In the case of an urban sanitary authority not being a Borough Council, or of a rural sanitary authority, as if the purposes of this Act were purposes for which they are authorized to borrow under the Public Health Acts.

V. In this Act—

The expression "technical instruction" shall mean instruction in the principles of science and art applicable to industries, and in the application of special branches of science and art to specific industries or employments. It shall not include teaching the practice of any trade or industry or employment, but, save as aforesaid, shall include instruction in the branches of science and art with respect to which grants are for the time being made by the Department of Science and Art, and any other form of instruction which may for the time being be sanctioned by that Department by a minute laid before Parliament and made on the representation of a local authority that such a form of instruction is required by the circumstances of its district.

The expression "manual instruction" shall mean instruction in the use of tools, and modelling in clay, wood, or other material.

VI. This Act shall not extend to Scotland or Ireland.

VII. This Act may be cited as the Technical Instruction Act, 1889.

PROFESSOR LOOMIS ON RAINFALL.[1]

THE subject of this chapter is the mean annual rainfall in all the different countries of the globe, with a discussion of the conditions favourable and unfavourable to rainfall, and an examination of individual cases of rainfall in the United States, Europe, and over the Atlantic Ocean, and the areas of low barometric pressure without rain.

To begin with, Prof. Loomis has compiled a list of 1427 stations, and arranged them in order of latitude. With each station is found its altitude, its mean annual rainfall, and the number of years of observation. This list would have been considerably larger if all the stations where the amount of rainfall is measured were quoted, for in England alone there are 2200 stations where rainfall is regularly measured, in the United States 2000, whilst the total number of stations in France is 1500. The plan adopted by the author has been to select a few stations from those countries which rejoiced in a plentitude of rain-gauges, but in regions where few stations exist all the measurements were used.

Following upon each enunciation of causes which affect rainfall is found a tabular statement demonstrating its truth.

The conditions favourable to rainfall, according to Prof. Loomis, begin with the fact that the north-east and south-east trade winds, on approaching the belt of calms near the equator, and being gradually deflected upward, are cooled by expansion, so that the aqueous vapour is condensed, and the belt of calms becomes a belt of rain. This equatorial rain-belt, of course, moves with the sun in declination, and some observations included in table lxxxiv. strikingly exemplify this movement by giving for twelve months respectively the number of rains in a hundred observations between latitudes 20° N. and 10° S., the maximum of falls moving with the sun.

A second cause for abundant rainfall is the influence of mountains, for when a strong wind meets a mountain it is forced up the side of the mountain, and elevated into a colder region, the result being that its vapour is precipitated by the cold of elevation. Table lxxxv. gives a comparison of the rainfall in two regions situated within twenty-five miles of each other, but of different altitudes, and from it the conclusion is deduced that the rainfall on a mountain from 4000 to 10,000 feet high is more than double that at neighbouring places near the sea-

[1] "Contributions to Meteorology," Chapter III., by Elias Loomis, LL.D., Professor of Natural Philosophy and Astronomy in Yale University, &c. Revised Edition. (New Haven, Connecticut, U.S., 1889.)

level. A third condition favourable to an abundant rainfall is proximity to the ocean, especially when the prevailing wind comes from the ocean. Capes and headlands projecting considerably into the ocean generally show a rainfall greater than interior stations only a few miles distant; and lastly, Prof. Loomis notes that the great and non-periodic depressions of the barometer are always accompanied by a considerable fall of rain, and that the average tracks of these depressions are marked by an excess of rainfall.

The following are some of the conditions unfavourable to rainfall. Fresh winds blowing in a nearly uniform direction throughout the year, such as prevail within a portion of the system of trade winds, especially in mid-ocean. The rainfall on Ascension Island is quoted as a case in point, observations for two years showing that the direction of the wind was south-east or very nearly so during the time, the rainfall during these two years being 2·31 and 4·30 inches respectively. This condition of things prevails over the Atlantic Ocean within the region where the trade winds blow with considerable force and are seldom interrupted.

A second condition unfavourable to rain is a position on the leeward side of a range of mountains running in a direction nearly at right angles to that of the prevalent wind. An illustration of this principle is seen on the Malabar coast of Hindustan. On the ocean side of the range of mountains the rainfall is 250 inches annually, whilst on the eastern side of the range the air is very dry, and the amount of the mean annual rainfall is less than 25 inches.

When there is a second range of mountains, parallel and within 100 or 200 miles of the first, the influence of this cause is considerably intensified, and this diminution is still more decided when a place is surrounded by mountains, or nearly so. Salamanca is so situated, and the mean annual rainfall there is less than 10 inches.

Elevated plateaus have generally less rainfall than insulated mountain peaks of an equal elevation; this is illustrated by the fact that Leh, being situated on that remarkable plateau of Tibet, has a mean annual rainfall of less than 3 inches. Another similar case is found in the tableland (the Punos) between two great chains of the Andes; and it is observed that the average height of the Sahara being over 1500 feet, this elevation may contribute in some degree to the smallness of the rainfall.

Another condition unfavourable to rainfall is the dryness of the atmosphere, under which head Prof. Loomis gives three special cases, viz. remoteness from the ocean, measured in the direction from which the prevalent wind proceeds, areas of high barometric pressure, and high latitudes. This last conclusion does not state that the average rainfall regularly diminishes as we go northwards, the same as the mean temperature; but if the mean annual fall be taken for every 10° of latitude the important influence on the amount of rainfall is very decided, and is emphatically exhibited in high latitudes. The general table of observations, arranged in order of latitude, which began this chapter, shows that for the four stations whose latitude exceeded 71° the mean annual rainfall was 7·44 inches, whilst the paucity of observations of the fall of rain or snow that have been made during the various Arctic expeditions also demonstrates the fact.

A review is next made of the regions which show a very small rainfall, and the causes inquired into where the observations of pressure, temperature, and humidity of the air, and the direction and force of prevailing winds rendered it possible to obtain some definite information as to the meteorological condition of the region.

Prof. Loomis has thoroughly investigated the conditions of rainfall in the United States, and from the tables of observations he arrives at the inference that the depression of the barometer accompanying extraordinary rainfalls is not very great, the average pressure at the low centre being 29·63 inches for the part of the United States north of latitude 36°, and the average pressure at the stations of greatest fall being 29·77 inches.

Table cxii. gives all the cases where the barometer fell below 29 inches at any station in the United States or Canada between September 1872 and June 1884, and also the station where the greatest rainfall occurred for the preceding twenty-four hours. The conclusion drawn from such a comparison is that a moderate depression of the barometer is as favourable to great rainfall as an extremely great depression, which would seem to indicate that rainfall has but little connection with barometric depression. It must, however, be remembered that the depression at the centre of a low area depends not merely upon the barometric gradient, but upon the geographical extent of the low area.

The following are some of the conclusions Prof. Loomis arrives at respecting the causes of rainfall in the United States. One of the most common causes of rain is an unstable condition of the atmosphere resulting from an unusually high temperature combined with unusual humidity. Another very common cause of rain frequently associated with this is a cold northerly or westerly wind in the western segment of the low area, and proximity to the ocean or to a large inland sea.

The investigation affords important evidence respecting the influence of rainfall upon areas of low pressure, viz.—

No great barometric depression with steep gradients ever occurs without considerable rainfall.

In great rain-storms the barometric pressure generally diminishes while the rainfall increases.

The greatest depression of the barometer generally occurs about twelve hours after the greatest rainfall.

A great fall of rain is favourable to a rapid progress of the centre of least pressure, while a small rainfall is generally attended by a less rapid progress.

It is also noted that some of the characteristics of areas of low pressure with little or no rain are:—

(1) Feeble barometric gradients.
(2) Moderate winds.
(3) Slow changes of barometric pressure.
(4) Slow progressive movement.

Whilst in similar areas of low pressure with excessive rainfalls all these conditions are reversed.

In order to study the influence of rainfall upon barometric pressure under different geographical influences, Prof. Loomis has compiled for Europe a similar set of tables to those concerning the United States. Of the 106 stations having a rainfall of not less than 2·5 inches in twenty-four hours, eighty-six are situated south of latitude 48°, and fifteen are north of latitude 48°, indicating that heavy rains are about six times as frequent in the south as in the north of that latitude. Prof. Loomis thinks that the summary of observations relating to Europe seems to indicate that great rains occur on the west side of the low centre more frequently than they do in the United States.

Tables have also been prepared showing the rainfall over the North Atlantic as far as observations permitted. An unexpected fact exhibited by these tables is the prevalence of rainfalls with the barometer somewhat above 30 inches.

A comparison of the results that have been obtained for the United States and for Europe brings Prof. Loomis to some important conclusions respecting the influence of local causes in modifying the relation of rainfall to barometric pressure.

The conclusions are, for stations east of the Rocky Mountains:—

(1) South of latitude 36°, a rainfall of 2½ inches in eight hours at any station occurs on the east side of a low area more frequently than on the west side in the ratio of 2·6 to 1.

(2) North of latitude 36°, a rainfall of 2 inches in eight hours at any station occurs on the east side of a low area more frequently than on the west side in the ratio of 2·8 to 1.

(3) A total rainfall of 9 inches in eight hours at all the stations east of the Rocky Mountains occurs on the east side of a low area more frequently than on the west side in the ratio of 6·2 to 1.

(4) Over the North Atlantic Ocean great rain areas occur on the east side of an area of low pressure more frequently than on the west side in the ratio of 2·6 to 1.

(5) In Europe a rainfall of 2½ inches in twenty-four hours at any station occurs on the east side of a low area more frequently than on the west side in the ratio of 2·0 to 1.

These results indicate that in the United States and Europe, as well as over the North Atlantic Ocean, great rainfalls are generally associated with a barometric pressure somewhat below the mean, and the precipitation occurs chiefly on the eastern side of a low area.

The relation of a rising to a falling barometer with rain points to the conclusions that at Philadelphia the amount of rain which falls while the barometer is descending is nearly three times as great as that which falls while the barometer is rising. The entire Atlantic coast of the United States north of latitude 36° exhibits results similar to those found for Philadelphia. Advancing westward from the Atlantic coast, the ratio of the precipitation when the barometer is falling, compared with that when the barometer is rising, changes somewhat rapidly, and before we reach the Mississippi River the ratio is reduced to 1·32.

In Great Britain the amount of rain with a falling is twice that with a rising barometer, but, advancing eastward, this ratio rapidly diminishes, and in Central Europe the precipitation is greater when the barometer is rising than when it is falling. Plates are appended, which exemplify in an emphatic manner all the facts that have been tabulated concerning rainfall. Five gradations of colour only have been used to indicate the rainfall of less than 10 inches to over 75 inches. By this means the main results have been rendered more prominent.

R. A. GREGORY.

THE SOURCES OF THE NITROGEN OF VEGETATION.[1]

NO problem relating to the nutrition of plants has given rise to so much discussion as that of the source of their nitrogen and the methods of its assimilation. It is obviously both a matter of the highest scientific interest, and also, owing to the high price of combined nitrogen in manures and the comparative ease with which it is washed out of the soil in the form of nitrates, one of great practical importance to the agriculturist and the community.

Ever since the discovery of the composition of atmospheric air by Priestley, Scheele, and Lavoisier, the question as to whether plants were able to absorb and utilize free nitrogen has attracted much attention. At the end of the last century, or beginning of this, Ingenhousz, Sennebier, Woodhouse, and De Saussure became interested in the subject.

Boussingault commenced his experiments in 1837; Ville, whose results conflicted with those of Boussingault, in 1849; and, shortly after, this last named investigator started a new series of experiments which confirmed his former conclusions that plants, under the conditions of the experiment, were not able to assimilate free nitrogen.

In 1857, experiments on the assimilation of free nitrogen by plants were started at Rothamsted; and in 1861 was published, in the Philosophical Transactions, the classical memoir of Lawes, Gilbert, and Pugh, on this subject.

In this earlier paper a brief history and summary of the results of other experimenters is given, and then the recent results obtained at Rothamsted. The conclusions arrived at were identical with those of Boussingault, that there is no evidence that plants assimilate nitrogen. Still the authors allowed that there were some difficulties with regard to the supply of nitrogen to leguminous plants, which assimilate from some source or another much more nitrogen than gramineous plants under similar conditions of supply of combined nitrogen.

It was admitted that, "if it be established that the processes of vegetation do not bring free nitrogen into combination, it still remains not very obvious to what actions a large proportion of the existing combined nitrogen may be attributed."

These views, that plants were unable to assimilate free nitrogen were widely and generally held for many years, though there have always been some dissentients.

In the meantime, however, the indefatigable investigators of Rothamsted have not been resting in the matter, but have added much to our exact knowledge of the supplies of combined nitrogen to the soil from the air, on the amount and nature of the combined nitrogen in soils and in crops, on the processes of nitrification in soils, and the amount of nitrogen removed from soils in crops and in drainage.

During the last few years the main question as to the availability of atmospheric nitrogen to plants has taken a somewhat different aspect: it is now often suggested that though the higher plants are unable to directly take up free nitrogen, yet indirectly it is brought under contribution in some way; the ways most generally favoured being either under the influence of electricity of low tension, or of microbes or some low forms of organisms; and by such means it is thought that nitrogen is brought into a form in which it is useful to the higher plants.

In Sir J. B. Lawes and Dr. Gilbert's new memoir they give a summary of some previously published Rothamsted results, chiefly relating to nitric acid in soils and subsoils; also of the results of Cameron, S. W. Johnson, Hampe, Wagner, and Wolff, on the assimilation of nitrogen by plants, from more or less complex organic bodies like urea, uric acid, hippuric acid, and tyrosine.

A number of new determinations of nitric acid in soils and subsoils, and of total combined nitrogen in the surface soils of the Rothamsted experimental plots are given; and also the results of numerous experiments with dilute solutions of organic acids on soils, to ascertain the action of such dilute acids, in some degree comparable to the acid sap of the roots of plants, on the organic nitrogenous matter of soils.

In the second part of the memoir are summarized the recent results and conclusions of other workers relating to the fixation of free nitrogen.

Probably the results of Berthelot, which have from time to time been published in the *Comptes rendus*, have influenced the opinions and the course of inquiry in recent years more than any others. In 1876 and 1877, Berthelot found that various organic compounds under the influence of the silent electric discharge, even of low tension, were able to fix free nitrogen, and concluded that such fixation of nitrogen takes place in ordinary soils under normal conditions. In 1885 he published results showing the fixing of free nitrogen by certain soils under conditions which led him to believe that the action must be due to the influence of micro-organisms, and to such action M. Berthelot seems now inclined to impute most influence in the matter. Although the gains in nitrogen, expressed in percentages, were very small, yet there was gain in all cases when the soils were exposed either in the open, or in a room, or in closed flasks, and no gain when the soils were sterilized. Unless there be some unrecognized source of error, such as might easily be imagined in the case of the freely exposed soils, one seems bound to accept Berthelot's conclusions. Dehérain's results at Grignon are next discussed; they are chiefly on the gains or losses occurring on experimental field plots, and are perhaps not of such a nature as to materially assist one at the present stage of the inquiry.

Joulie's results, as given in the *Bulletin de la Société des Agriculteurs de France* in 1886, showed exceedingly large gains of nitrogen, which he is inclined to ascribe to the action of microbes; here the gains of nitrogen were certainly more than take place in ordinary farm practice, and occurred with buckwheat, which is not usually considered as a "nitrogen collector."

Dietzell's experiments are mentioned; in all cases but one, in which there was a slight gain in nitrogen, the results are fully accordant with established facts. B. Frank, who has recently written a paper on the whole aspect of the question, has published some experiments of his own. He concluded, as have others, that two opposite actions are at work in the soil—one setting nitrogen free, and the other bringing it into combination, the latter being favoured by vegetation—but that there is no decisive evidence to show how this combination is brought about; it does not necessarily follow that the plant itself effects the combination. Some of Frank's experimental conditions, however, were considerably removed from those occurring in the ordinary course of farm practice.

The very important and most interesting experiments of Hellriegel and Wilfarth follow. The first of these were described at the Berlin meeting of the *Naturforscher-Versammlung*, in 1886; subsequent experiments were described at the Wiesbaden meeting in 1887, and they were further given in a paper by König, published in Berlin in 1887; but the full text and details of their work were not published in time for Messrs. Lawes and Gilbert to refer to. A paper on these results appeared last November in *Beilageheft zu der Zeitschrift des Vereins für die Rübenzucker-Industrie*, and the work of these investigators is described by M. Vesque in the January number of *Annales Agronomiques*.

The experiments date from 1883 onwards, and were on cereals, buckwheat, rape, and various leguminous plants. The plants were grown in pots in washed siliceous sand, to which the necessary cinereal constituents were added. In this all the plants grew normally until the nitrogen in the seed was used up; then the plants not belonging to the Leguminosæ ceased growing until supplied with some combined nitrogen, nitrate of soda was used, when growth was proceeded with almost exactly in proportion to the amount of nitrogen supplied. With the Leguminosæ the results were more eccentric: sometimes the plants died of nitrogen-hunger; sometimes after a time of such hunger they recovered and produced abundant growth. To

[1] "On the Present Position of the Question of the Sources of the Nitrogen of Vegetation, with some New Results, and Preliminary Notice of New Lines of Investigation." By Sir J. B. Lawes and Prof. J. H. Gilbert. Phil. Trans. 1889, clxxx. B. pp. 1–107.

the sterile soil with the young plants there was added in a large number of cases a small quantity of an extract of a garden soil; the extract used contained less than one milligramme of nitrogen; the oats, rape, and buckwheat remained undeveloped, but the leguminous plants soon became deep green and grew vigorously. If the soil extract were previously sterilized by heat, it produced no effect. Moreover the soil used in the preparation of the extract was of importance; with peas any soil extract answered, but not so with lupins and sainfoin; with these plants, to render success certain it was found necessary to use an extract of a soil which had previously grown the same plants. Some experiments were also made in large sealed flasks, to which carbon dioxide was admitted at intervals; in these the results were practically the same as in free air, showing that it was not the combined nitrogen of the air which was absorbed.

It was also found that whilst on the leguminous plants which developed well, either with or without the addition of soil extract, the characteristic tubercules of papilionaceous plants were well marked, on those which did not develop in the sterile soil, and also on plants grown in sterilized soil to which nitrate had been added, and which plants developed at the expense of the added nitrogen, but did not assimilate free nitrogen, there were no tubercules. Hence there is obviously some connection between the production of the tubercules and the assimilation of the free nitrogen. In all cases where free nitrogen is presumably assimilated by the plant, the soil is also enriched in nitrogen, the more so when the plant growth is more vigorous, and this excess of nitrogen in the soil is almost entirely in organic combination.

The general conclusions are that leguminous plants, though they are able to make use of combined nitrogen in similar forms to those the graminaceous plants utilize, yet differ from this latter order of plants in being able to use some other form of nitrogen, not that existing in the soil. This second source of nitrogen must be the free nitrogen of the air, which the Leguminosæ utilize through the agency of certain micro-organisms which are in symbiosis with them, and exist in the tubercules of the roots of this order of plants.

The results obtained by von Wolff at Hohenheim, from 1883 onwards, are mentioned. Wolff is not inclined to admit that plants assimilate free nitrogen, but thinks that the only remaining hypothesis is that certain plants can appropriate the combined nitrogen of the air, either directly through their leaves or more probably after absorption by the soil. A porous soil probably absorbs far more nitrogenous compounds from the air than an equal superficial area of dilute acid, as used in experiments by Schlœsing, Kellner, and Müller. He admits, however, that it is difficult to see why the grasses are unable to benefit by this equally with the legumes.

W. O. Atwater has published three papers on various aspects of the subject in the *American Chemical Journal*. In these papers he gives results of his own experiments and also discusses those of others. He concludes that in many of his experiments with peas, when the growth was normal, half or more of the total nitrogen of the developed plants was obtained from the air. In what way the nitrogen was acquired, the experiments do not show, but Atwater inclines to the idea that the plants themselves directly acquired the atmospheric nitrogen. The conclusion of this second part of the memoir gives some recent experiments and opinions of Boussingault on the subject. He remained strongly of the opinion that plants were unable to assimilate free nitrogen; although, as is here pointed out, some of his experiments in 1858 and 1859, with lupins, might be considered as leading to such a conclusion.

The third part of the memoir gives a summary and general considerations and conclusions.

Regarding the evidence relating to other sources than free nitrogen, Lawes and Gilbert have shown that the amount of nitric acid remaining in a soil is much less after the growth of a crop than under corresponding conditions without a crop. Also that nitrification in soils is more active where leguminous crops are grown than where gramineous plants only are present; and that deep-rooted leguminous plants like *Medicago sativa* or *Melilotus leucantha* take up more nitric acid from the soil than shallower-rooted leguminous plants like *Trifolium repens*. But the supply of nitric acid in some soils, such as clover-exhausted land or bean-exhausted land, is inadequate to account for the nitrogen taken up by other leguminous crops grown on such land. No very definite conclusions could be drawn from the Rothamsted experiments as to the power of the acid sap of roots to take up nitrogenous organic matter from the soil, though it is seen to be not improbable that green-leaved plants can "take up directly, and utilize, amide bodies rendered soluble within the soil by the action of their acid root sap."

Our authors in conclusion point out that, since experimenting in free air instead of in closed vessels, as in Boussingault's and their own researches, has become common, there has been a great accumulation of evidence tending to indicate the fixation of free nitrogen. The modes of explanation of the gain of nitrogen are: that it has been absorbed from the air, either by the soil or by the plant; that there is fixation of free nitrogen within the soil by the agency of porous and alkaline bodies; that there is fixation in the soil by the agency of electricity; that there is fixation by the plant itself; that there is fixation under the influence of micro-organisms within the soil. The balance of recorded evidence is undoubtedly in favour of the last-mentioned mode of explanation. "Indeed, it seems to us," say Lawes and Gilbert, "that, if there be not experimental error, there is fixation of nitrogen within the soil, under the influence of micro-organisms, or other low forms of life." But they think that final judgment must be held in abeyance for the present. Most of their own and Boussingault's previous experiments excluded, by their conditions, the action of electricity or of micro-organisms.

They then consider some of the facts of agricultural production in their bearing on the question as to how far the establishment of the reality of the fixation of free nitrogen is necessary to the solution of problems of agricultural production. They point out that the loss of nitrogen in ordinary farm practice is not so great as Berthelot and others have assumed; the annual loss of nitrogen by cropping in Great Britain, for example, is probably under 20 pounds per acre. The loss by drainage may in some cases be considerable, and in special cases there may be loss by evolution of free nitrogen. Probably the loss of free nitrogen from the plant itself during growth, which is assumed by some, does not occur. The accumulation of combined nitrogen which occurs in the surface soil of pastures is not conclusively explained, but it may have a subsoil origin, and this assumption has as much evidence in its favour as that it has an atmospheric origin. In the soil and subsoil of Rothamsted, to a depth reached by the deeper-rooting plants, there is 20,000 pounds of combined nitrogen per acre; in very many of the soils of this country there is more, though in some less than this: the accumulation of nitrogen in the surface soil may well be due to nitrogenous crop-residue, the nitrogen of which comes principally from the subsoil. Again the natural fertility of most soils is without doubt due to the accumulation of ages of natural vegetation with little or no removal; and the amount of nitrogen even now brought into combination under the influence of electricity, over a given area, would be sufficient, with growth and little or no removal, to account for the accumulations in natural prairie or forest lands even of the richest.

The Rothamsted experiments have shown that after growing crops for many years without nitrogenous manures there has always been a diminution of nitrogen in the top soil; this has been found to be the case with diverse crops, including gramineous, cruciferous, chenopodiaceous, and also leguminous crops, and with a four-course rotation of crops. There has not been compensation of nitrogen from the air, or at all events to the extent of the annual losses. "The agricultural production of the present age is, in fact, as far as its nitrogen is concerned, mainly dependent on previous accumulations; and as in the case of the use of coal for fuel there is not coincident and corresponding restoration, so in that of the use or waste of the combined nitrogen of the soil, there is not evidence of the coincident and corresponding restoration of nitrogen from the free to the combined state."

It is not yet conclusively proved that the whole of the nitrogen of leguminous plants comes from the subsoil; it is equally not proved that it comes from the air; though in the case of crops belonging to other natural orders it may be affirmed that atmospheric nitrogen is not the source. May it be that the development of organisms capable of bringing free nitrogen into combination within the soil is favoured by leguminous growth and crop-residue, as there can be little doubt is the case with the organisms which produce nitrification?

Frank has shown that on the roots of certain trees, especially the Cupuliferæ but also on willows and some Coniferæ, is a fungus-mantle which is believed to be in true symbiosis with the higher plant; and it may well be supposed that the fungus partly assists the tree by bringing the organic nitrogen of the soil into a form in which it becomes available to the chlorophyllaceous plant; much in the same way as has been observed by Gilbert in the case of fairy-rings, where the fungus, so to speak, prepares the nitrogenous nutriment for the grass. That the tubercules that are nearly always present on the roots of leguminous plants are in some way connected with the assimilation of nitrogen by the plants is an hypothesis that is gaining ground. Much study has of late years been devoted to the morphology and functions of these tubercules by, amongst others, Tschirch, Brunchorst, Frank, Van Tieghem, Lundström, and Marshall Ward; and still more recently by Bréal, Beyerinck, and Prazmowski. It seems almost certain that these tubercules contain micro-organisms, which are the proximate cause of the excrescences, and these may live in symbiosis with the legumes, and prepare their nitrogenous food possibly from free nitrogen. The tubercules are richer in nitrogen than the roots themselves, and some observers look upon them as being merely reservoirs of nitrogenous nutriment, not as manufactories. Beyerinck (*Botan. Zeitung*, 1888) has obtained and cultivated an organism which he calls *Bacillus radicicola*, from these tubercules, and studied some of its reactions. It seems very probable that further study of these tubercules of the Leguminosæ may put us on the right track for solving the mysteries of the nitrogenous nutrition of this order of plants.

In a postscript to the memoir the authors state that they have started some experiments with leguminous plants much on the same lines as those of Hellriegel and Wilfarth. The results of these experiments will be looked forward to with very great interest.

This memoir is a most welcome and solid contribution to a most important problem. It is quite obvious that the last word on the subject has not been said, and probably very much more work must be done before it is. The authors, from their own labours and thought on the subject, continued through so many years, are well able to criticize the work of others, and this they have here done, as far as most of the important papers published up to date are concerned, in an able and frank manner. If leguminous plants are able to avail themselves of the free nitrogen of the air, or if soils are able, through the agency of microbes or in other ways, to fix free nitrogen, the exact conditions necessary for the accomplishment of these ends is not yet known. The conditions of risk and exposure to accidental sources of nitrogen-gain in small experiments in the open air are very great, and experiments made under such conditions require very careful verification. Also the methods of nitrogen determination used should be subjected to rigorous investigation and control, as also the methods of taking the samples used in analysis, which in the case of a complicated body like a soil presents great difficulty in obtaining a perfectly homogeneous mixture. The exact limits of experimental error in the various determinations want investigation. The subject, from its important practical bearings, is worthy the attention of a scientific commission who could give undistracted attention to it. E. K.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—An examination will be held at Queen's College, in the first week of October, to fill up at least two open Classical Scholarships for candidates proposing to commence residence this October, and one open Scholarship in Natural Science (Chemistry and Physics) for candidates proposing to commence residence in October 1890.

Classical candidates must not have exceeded nineteen years, and Natural Science candidates eighteen years, on October 10, 1889.

A further notice will be issued.

SCIENTIFIC SERIALS.

American Journal of Mathematics, vol. xi. No. 4 (Baltimore, July 1889).—Prof. Cayley opens the number with a resumption of his memoir on the surfaces with plane or spherical curves of curvature (pp. 293–306).—The circular cubic with double focus on itself is treated by Schröter and Durège (*Crelle*, Bd. v.). Mr. F. Morley, writing on the geometry of a nodal circular cubic (pp. 307–16), gives a geometrical account, illustrated by figures, of the case when the curve, in addition, is nodal. Some properties of the special case when the inflexion is at infinity are given by Dr. Booth (*Quarterly Journal*, vol. iii.) in his discussion of the logocyclic curve (cf. vol. i. of his "Collected Papers," cap. xxx.).—The next paper supplies a defect in MM. Briot and Bouquet's "Propriétés des fonctions définies par des équations différentielles" (*Journ. de l'École Pol.*, cap. xxxvi.): it is entitled, "On the Functions defined by Differential Equations, with an extension of the Puiseux polygon construction (see *Journ. de Math. pures et appliquées*, i. 15) to these equations" (pp. 317–28), and is written by Mr. H. B. Fine.—In the memoir "Sur les solutions singulières des équations différentielles simultanées" (pp. 329–72), M. Goursat extends results obtained by M. Darboux to simultaneous differential equations and to equations of higher order.—The number, and volume, concludes with a note by J. C. Fields, on the expression of any differential coefficient of a function of any number of variables by aid of the corresponding differential coefficients of any n powers of the function, where n is the order of the differential coefficient (pp. 388–96).—All these papers are, of course, purely mathematical: there is a physical paper (pp. 373–87) by Prof. H. A. Rowland, entitled "Electro magnetic Waves and Oscillations at the Surface of Conductors." The calculations are founded on Maxwell's equations. "In these equations occur two quantities, J and ψ. Maxwell has given the reasons for rejecting ψ, and has shown that neither J nor ψ enter into the theory of waves. In order, however, that there shall be no propagation of free electricity in a non-conductor, the components of the electric force must satisfy the equation of continuity, and this leads to components of the vector potential satisfying the same equation, and $J = 0$ therefore. I have satisfied myself that there is absolutely no loss of generality from these changes."

IN the *Nuovo Giornale Botanico Italiano* for July, Sig. A. Bottini has an interesting article on the structure of the olive, especially on that of the several layers of tissue of which the ripe fruit is composed. A disease to which the crop has been recently liable he believes to have been erroneously attributed to a parasitic fungus, *Septoria oleaginea*.—The greater part of this number is occupied by the proceedings of the meeting of the Botanical Society of Italy held in Florence.—Prof. Arcangeli gives an account of a series of experiments on the amount of heat due to the respiration of fungi. The greatest elevation of temperature he finds to amount to 1°·25 C. in the case of *Lepiota excoriata*. In all cases the elevation of temperature is most conspicuous about midday, or early in the afternoon.—The colouring-matter of the cones of *Abies excelsa* is stated by Sig. L. Macchiati to be due to a mixture of three distinct substances, two of them crystallizable, accompanied by a waxy substance.

Das Wetter for July contains:—(1) The second part of an explanatory discussion, by Dr. Wagner, of the recently published instructions for the observers of the Prussian Meteorological Institute. The points referred to relate especially to rainfall and thunderstorm observations. The author refers to the variability of rainfall values both as regards time and place, and to the necessity of stations near each other, to explain the irregularities of the yearly amounts. It is only since 1887 that such a system has been established in North Germany, where it is proposed to raise the number of stations to 2000, which will then only give one for about 77 square miles. The hours of observation are also discussed, the result being that the usual morning observation cannot be altered; but the instructions direct that the rainfall should be set down to the day upon which it is observed; this has generally been done in Prussia, whereas in other countries it is put down to the previous day. The author refers to the importance of the measurement of rain during the passage of thunderstorms, and also to the advantage to be derived from the more general use, at stations of the second and third order, of simple registering barometers and thermometers, similar to those of Richard Frères.—(2) A criticism of Herr Falb's weather predictions taken from an article in the *Göttingen Zeitung*. M. Falb bases his theory on the influence of the sun and moon upon the interior of the earth, and upon the surrounding media of air and water, and calculates certain "critical days" from the relative positions of these bodies. The author of the article has checked the predictions sent to the German agricultural Press since April 12, and points out that although the weather of May has been unusually warm, no mention of the fact was contained in the predictions, and concludes with the remark that a theory which shows such little success, as in the comparison in question, is useless to the agriculturist.—(3) A description, by Dr. Wagner, of the new popular Observatory, "Urania," opened on July 3, in Berlin, on the site of the Exhibition buildings. It contains a large equatorial, over 16 feet in length, with a lens of about 12½ inches in diameter, a large number of instruments and microscopes, and a spacious lecture theatre.

SOCIETIES AND ACADEMIES.

LONDON.

Chemical Society, June 20.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—Observations on the melting-point of some salicylic and anisic compounds, by Dr. W. H. Perkin, F.R.S. The author, in 1867, described methylated and ethylated salicylaldehydes as colourless liquids which do not solidify when cooled in a freezing mixture, whereas Voswinckel states that methylated salicylaldehyde is a solid melting at 35° (*Ber. der deut. chem. Gesellsch.*, 1882, 2024). Further experiments show that although the methylated aldehyde does not readily crystallize in a freezing mixture it can be made to do so, but the crystals so obtained melt at 2°·7–3°. Prismatic crystals having the melting-point described by Voswinckel were once obtained on evaporating an ethereal solution of the aldehyde, and it is found that if the oily aldehyde is touched with one of these it immediately becomes a solid mass, having a melting-point of 35°; when these crystals are fused, and the resulting oil cooled in a freezing mixture, crystals melting at 2°·7–3° are again formed. It is therefore established that methylated salicylaldehyde forms crystals of two kinds, having melting-points differing by about 32°.—The action of propionyl and butyryl chloride on phenol, by the same. When phenol is acted upon by propionyl chloride, a secondary product, propionyl phenol, $C_3H_5O \cdot C_6H_4 \cdot OH$, is formed in addition to phenyl propionate. A corresponding reaction occurs when phenol is treated with butyryl chloride.—The nature of solutions as elucidated by a study of their freezing temperatures, by Mr. S. U. Pickering. By determining the freezing temperatures of mixtures of sulphuric acid and water, the author has obtained results which in his opinion confirm the existence in solution of the majority of the hydrates of sulphuric acid which have been indicated by a study of the densities, heat of dissolution, heat capacity, and electric conductivity of these solutions (cf. p. 166).—Note on the determination of the molecular weight of substances in solution, especially colloids, by Prof. H. E. Armstrong.—The correspondence between the magnetic rotation and the refraction and dispersion of light by compounds containing nitrogen, by Dr. J. H. Gladstone, F.R.S., and Dr. W. H. Perkin, F.R.S.—Note on the oxidation of paradiamines, by Prof. R. Meldola, F.R.S., and Mr. R. E. Evans. The authors find that the amido-groups of paraphenylenediamine are split off in the form of ammonia, when it is oxidized to quinone by the action of potassium bichromate.—Monobenzyl-derivatives of the phenylenediamines, by Prof. R. Meldola and Mr. J. H. Coste. Monobenzyl meta- and para-phenylenediamines have been prepared, and their oxidation products examined. The paradiamine, when oxidized with an equimolecular proportion of benzylaniline, yields an unstable greenish-blue indamine, and when oxidized with two molecular proportions of benzylaniline at the temperature of boiling water, forms an azine or benzylated saffranine which is of interest as being produced, in contradiction to the generally received view, from one molecule of a diamine, and two molecules of a secondary instead of a primary monamine.—Note on a yellow pigment in butterflies, by Mr. F. G. Hopkins. The colour effects on the wings of lepidopterous insects are for the most part probably due to purely physical causes, but in some cases pigments are undoubtedly present. A yellow pigment, which is found in its purest form in the common English brimstone butterfly, and may also be detected in the wings of a very large number of day-flying Lepidoptera, can be obtained from the wings by simple treatment with hot water, in which it is freely soluble, and may be identified by its yielding a marked murexide reaction, when evaporated with nitric acid, and afterwards treated with ammonia or potash. The common brimstone butterfly yields somewhat less than a milligram of pigment from each insect; larger foreign species, such as those belonging to the species *Callidryas*, may yield as much as 4–5 milligrams. Examination of the pigment reveals its near relationship to mycomelic acid, a yellow derivative of uric acid; and the author suggests that it may possibly be a condensation product of uric and mycomelic acids.—Zinc dextrosate, by Mr. A. C. Chapman.—β-bromonaphthalenesulphonic acids, by Mr. R. W. Sindall. It is found that dichloronaphthalenes are chiefly formed when the chlorides of the β-bromonaphthalenesulphonic acids are distilled with phosphorus pentachloride, the bromine atom becoming displaced by chlorine.—Isomeric change in the naphthalene series, No. 5; β-iodonaphthalenesulphonic acids, by Prof. H. E. Armstrong and Mr. W. P. Wynne. A further contribution to the study of isomeric change in the naphthalene series, in which additional evidence, derived from the investigation of the acids obtained on sulphonating β iodonaphthalene under varied conditions, is adduced in favour of the view that the β-derivatives of naphthalene are formed by isomeric change from α-derivatives and not by direct substitution.—The formation of sulphones on sulphonating naphthalene-derivatives by means of chlorosulphonic acid, by Mr. W. M. Heller.—Note on the hydration of cyanides, by Prof. H. E. Armstrong. Unlike the α-derivative, β-cyanonaphthalene cannot be sulphonated; if, however, it is dissolved in fuming sulphuric acid, and the solution poured into water, it is completely converted into the amide of naphthoic acid. In like manner trichloracetonitril, $CCl_3 \cdot CN$, slowly combines with sulphuric anhydride, forming a crystalline compound which on treatment with water undergoes immediate and complete conversion into trichloracetamide. These cases appear to afford striking evidence in favour of the view that hydrating and hydrolytic agents act by forming compounds directly attackable by water; they serve, in fact, to support the integration rather than the dissociation hypothesis of chemical change.—The existence of salicylic acid in certain genera of the *Liliaceæ*, by Dr. A. B. Griffiths. The author states that he has isolated salicylic acid from the leaves, stems, &c., of *Tulipa*, Yucca, and *Hyacinthus*.—On the oxidation products of acenaphthene, by Mr. T. Ewan and Dr. J. B. Cohen.—Schützenberger's process for the estimation of the oxygen dissolved in water, by Sir H. E. Roscoe, F.R.S., and Mr. J. Lunt.—Isomeric change in the phenol series (third notice), by Mr. A. R. Ling.

EDINBURGH.

Royal Society, July 1.—Dr. John Murray, Vice-President, in the chair.—Prof. Tait communicated a paper, by Dr. G. Plarr, on the determination of the curve, on one of the co-ordinate planes, which forms the outer limit of the positions of the point of contact of an ellipsoid of revolution which touches all three planes of reference. By considering an ellipsoid of revolution the number of the equations to be finally solved is reduced to two.—Mr. A. Crichton Mitchell read a paper on the thermal conductivity, and the specific heat, of manganese steel. The thermal conductivity is one-seventh of that of iron, and increases with rise of temperature, but only at half the rate at which the conductivity of iron increases. The specific heat is 1·008 times that of iron—both increasing at the same rate with rise of temperature.—Sir W. Turner described the placentation (zonary) of the halicore dugong.—Dr. W. Peddie discussed the question Does the co-efficient of absorption depend upon the intensity of light? So far as his experiments have gone the answer is (as has hitherto been assumed) in the negative. He used a diverging beam of light, the intensity varying from 1 to 50.—A paper, by Dr. A. B. Griffiths, on the renal organs of the Nematoidea, was submitted.

July 15.—Prof. Chrystal, Vice-President, in the chair.—Prof. Tait read a paper, by Captain P. Weir, on an azimuth diagram, and also read a note by himself on the same.—Two papers, by Sir W. Thomson, on molecular arrangement, and on electrification by flame, respectively, were submitted.—Dr. R. W. Felkin discussed the geographical distribution of some tropical diseases.—Prof. Tait read a note on the compressibility of solutions of sugar. Sugar in solution increases the internal pressure, but not to the same extent as common salt does.—Prof. Berry Haycraft read a paper written by himself in conjunction with Dr. C. W. Duggan, on the coagulation of serum albumen, serum globulin, egg albumen, and vitellin.—Dr. Alex. James discussed a new point in connection with the latent period of muscle contraction.—Prof. Tait read a paper on the time of impact as depending on the masses of the impinging bodies. In the substances experimented on the distortion is proportional to a power of the kinetic energy.—Dr. Alex. Bruce communicated a paper on the segmentation of the nucleus of the oculo-motor nerve, and he also read another on the upward continuation of the spinal cord.—Dr. P. J. White read a description of the skull and visceral arches of *Tæmargus microcephalus*.—Prof. Tait submitted a paper, by the Rev. M. M. U. Wilkinson, on the scalar equations which represent the relations connecting n points. He also read a paper by himself on some novel quaternion formulæ.—Prof. Crum Brown communicated a paper by Prof. Letts and Mr. R. F. Blake on benzyl phosphines and the action of alcohols upon a mixture of phosphorus and phosphorus iodide.—Prof. Tait communicated a paper, by Prof. C. N. Little, on the non-alternate ± knots of the eighth and ninth orders.—The Chairman gave a review of the session.

SYDNEY.

Royal Society of New South Wales, June 5.—Prof. Liversidge, F.R.S., President, in the chair.—The Chairman announced that the Council had awarded the Society's bronze medal and a money prize of £25 to Mr. Thomas Whitelegge, for his paper on the marine and fresh-water invertebrate fauna of Port Jackson and the neighbourhood.—The following papers were read:—Note on the composition of two sugar plantation soils, by W. A. Dixon; and the Australian aborigines, by W. T. Wyndham.—Three new meteorites were exhibited by Mr. H. C. Russell, viz. two from Barratta Station, thirty-four miles north of Deniliquin, weighing 31½ pounds and 48 pounds, sp. gr. 3·706 and 3·429 respectively, and one from Gilgoin Station, near Brewarrina, 67½ pounds, sp. gr. 3·857.—In the course of some remarks respecting the recent heavy rainfall, Mr. Russell (the Government Astronomer) stated that he had no hesitation in saying that if rain equal to that which fell in and around Sydney (*i.e.* 20 to 26 inches) had fallen generally over the catchment areas of Windsor, Richmond, the upper parts of the Hawkesbury, and in the valley of the Hunter, most if not all the towns on their banks would have been swept away.—Prof. Anderson Stuart exhibited (1) the kymoscope, an apparatus he had devised for showing the action of the heart upon the blood in the circulatory system, also the difference in the pulse beats; (2) an appliance or means of showing that the shape of the chest is largely due to gravitation.

PARIS.

Academy of Sciences, July 22.—M. Des Cloizeaux, President, in the chair.—Summary of the solar observations made at the Observatory of the Collegio Romano during the second quarter of the year 1889, by M. P. Tacchini. During this period the solar spots have continued to diminish in number, so that the minimum appears now to have been reached. The protuberances also show a perceptible decrease, their height and expansion being even inferior to those of the previous quarter.—Two solar eruptions, by M. Jules Fenyi. The forms are here reproduced of the two eruptive protuberances of September 5–6, 1888, described in the *Comptes rendus*, vol. cviii. No. 17.—Restoration of the meridian and curve of mean time traced by Monge on the wall of the Ecole de Génie at Mézières, now the Prefecture of the Ardennes, by M. Cochard. At the request of the Mayor of Mézières, the author has carefully restored this interesting monument of the illustrious geometrician, which appears to have been executed by him some time between the years 1780 and 1784. Monge's dial is 5·20 m. high, distance taken on the meridian between the two solstices.—On the variations in the intensity of the current during the process of electrolysis, by M. N. Piltschikoff. In continuation of his previous note on the initial phase of electrolysis (*Comptes rendus*, March 25, 1889), the author here describes a curious phenomenon of transformation of molecular into electric energy, which he has observed in the course of his researches.—On the double elliptical refraction of quartz, by M. F. Beaulard. In a previous communication (*Comptes rendus*, vol. cviii. p. 671), the author described a new method of studying the phenomenon of double elliptical refraction presented by quartz at a direction oblique to the axis. Here he gives the first results of his researches carried on by means of this method.—On the zinc and cadmium chromites, by M. G. Viard. By modifying M. Gerber's process the author has succeeded in obtaining the crystallized chromites of zinc and cadmium which are here described. Their respective densities are 5·29 at 13° and 5·79 at 17°.—On the formation of crystallized alkaline and alkaline-earthy platinates at high temperatures, by M. G. Rousseau. The author here deals with the platinates of baryta and soda, which are shown to be as stable as the manganates and ferrites. They offer a fresh example of the formation of compound bodies at a temperature higher than that at which they are destroyed.—Quantitative analysis of the bicarbonate of soda in milk, by M. L. Padé. During his researches into the causes of the disappearance of the greater part of the alkaline element in the soluble ashes of milk, to which the bicarbonate of soda has been added, the author has discovered an exact method of effecting the analysis of this salt. During combustion about two-thirds of the carbonate of soda are transformed to the phosphate of soda and the carbonate of calcium by reacting on the phosphate of calcium contained in the milk. According to this transformation the phosphate of soda is contained in the ashes of a milk to which the carbonate of soda has been added. But the soluble ashes of a pure milk being but slightly alkaline, and containing only traces of phosphoric acid, in order to ascertain exactly the quantity of bicarbonate of soda that has been added, all that is needed is to take the alkalinity of the ashes and analyze the phosphoric acid contained in them.—Study of a molar of an elephant and of the process by which it is fixed in the maxillary, by M. V. Galippe. The recent death of an elephant in Paris has afforded the author an opportunity of studying the general structure of the gum in this animal, as well as certain pathological lesions, the analysis of which is here given in detail.—Papers were contributed by M. J. Macé de Lépinay, on the interference fringes produced by extended luminous sources; by M. Ad. Carnot, on the ammonio-cobaltic tungstates and vanadates; by M. E. Duvillier, on α-diethyl-amido-propionic acid; by M. J. Courmont, on a new bacillary tuberculosis of bovine origin; and by M. H. Wild, on the earthquake of Werny indicated by the magnetic and electric registering apparatus of Pavlovsk.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Proceedings of the National Electric Light Association at its Ninth Convention at Chicago (Boston, Mass.).—The Respiratory Functions of the Nose: G. Macdonald (Watt).—Oceania, Linguistic and Anthropological: Rev. D. Macdonald (Low).—My Lyrical Life: G. Massey (K. Paul).—Memoir on the Anatomy of the Humpback Whale: J. Struthers (Edinburgh, Maclachlan and Stewart).—The Theory of Credit, vol. i.: H. D. Macleod (Longmans).—Health Troubles of City Life: G. Herschell (Hamilton).—Reports of Geological Explorations during 1887–88 (Wellington, N.Z.)—Twenty-third Annual Report of the Colonial Museum and Laboratory (Wellington, N.Z.).—References to Papers in Anatomy: J. Struthers (Edinburgh, Maclachlan and Stewart).—Journal of the Institution of Electrical Engineers, No. 81 (Spon).

CONTENTS.

THURSDAY, AUGUST 8, 1889.

EMPIRICAL LOGIC.

The Principles of Empirical or Inductive Logic. By John Venn, Sc.D., F.R.S., Fellow and Lecturer in the Moral Sciences, Gonville and Caius College, Cambridge. (London: Macmillan and Co., 1889.)

THOSE familiar with Dr. Venn's previous logical writings felt sure that his new contribution would at least be something very different from an ordinary text-book. There is a novelty, perhaps something of a quaint peculiarity, in the manner of viewing and illustrating his subject, which gives to the author's works an appearance of originality which might be easily confused with that which is due, as in the case of such a treatise as Mill's "Logic," to a radically new conception. And to say this in these days, when logical text-books are multiplied, and, as some would think, all the old problems have been finally threshed out, is no small praise. In the less frequently explored fields already traversed by Dr. Venn—the logic of probability and symbolic logic—there was, of course, more room for such fresh treatment. This freshness is, however, just as conspicuous in the new treatise, which goes over the well-trodden ground of common logic. If anybody is stupid enough to think that logic is necessarily a dry subject, he may be recommended to look into Dr. Venn's last treatise. It is brimfull of shrewd observation, of apt illustration taken from the least conventional sources; more than this, it has humour, and it has fancy—a logician's, of course, but of a genuine quality.

In his general stand-point the author is, as the title of his book tells the expert, and as he fully discloses in his introductory chapter, not far from that of Mill. That is to say, he is an out-and-out materialist. Logic is not, as the formalist says, concerned only with the mind's thought and its normal forms, but occupies itself about the relation of this thought to objective fact or existence—that is, about objective truth. Hence here, as with Mill, we find the reference to reality running through the whole treatment of the subject. This emphasizing of the objective aspect is made sufficiently plain by the fact that, in his first chapter, before taking up the common topics, terms, propositions, &c., he deals at great length with the "physical foundations of inference," the assumptions with respect to the nature of the external world with which the logician sets out. In some directions, indeed, Dr. Venn carries this objective reference further than Mill, and with good results. Particularly valuable is the account of the meaning of reality or objective truth in the case of fictitious ideas, as "dragon." At the same time, our author is very far from making logic a purely objective science in the sense in which the physical sciences are objective. Having to give an account of and to provide rules for inference, it must at every step take into account the subjective aspect as well. Thus it has to consider facts so far as they are known, and, whilst it insists that names are representative of real things, it no less clearly contends that these names sum up and embody the amount of knowledge we happen to possess of the realities at any particular time. The steady grasp of this twofold aspect of the subject-matter of logic gives Dr. Venn a great advantage in the treatment of details. This is strikingly illustrated in his whole account of the connotation of names, and the related subject, definition. What a common name, *e.g.* "gold," means is of course a group of qualities known to exist in certain real things; but a glance shows us that these are not all the qualities that exist in the things, but only a certain portion of these conventionally selected. So again, in dealing with hypothetical propositions, the author turns his recognition of the double aspect to good account. A hypothetical statement, of the form, "If the summer is hot, the supply of water will be diminished," has at once a reference to clear objective fact, and to the mind's doubt or ignorance. The mind's attitude of doubt is seen in the very form of the supposition, "*If* the summer is hot," the objective certainty reveals itself in the inference confidently drawn from the supposition. One may add that it is this same just recognition of the equal rights of subject and object in logic which accounts for his taking a more modest view of induction than Mill. He tells us in his preface that the title "Empirical Logic" is intended to show that "no ultimate objective certainty, such as Mill, for instance, seemed to attribute to the results of induction, is attainable by any exercise of the human reason." Mill's confident repose on a system of universal law has been rudely handled by writers like the late Prof. Green, who denied his right to reach such universality on his purely empirical or Humean basis. And now we have scientific men like the late Profs. Clifford and Jevons, and Dr. Venn, urging from Mill's own empirical stand-point that experience can never guarantee such perfect universality.

In the case of a work like the present one it is difficult for the reviewer to give, by means of a few typical references, the scope and gist of the argument. As already hinted, it is not in any sense a new logical system. Indeed, it can hardly be called a complete system at all. It does not take us in an orderly, systematic manner through all the well-recognized divisions of the subject. Thus a large part of the domain of the common syllogistic logic is very slightly dealt with, if at all; no reference being made to the so-called laws of thought, or the axioms which underlie the thinking process so far as this is merely self-consistent. Nor even if we view it as a treatise on inductive logic can Dr. Venn's work be called complete, since some of the most important matters appertaining to induction—for example, experiment in relation to observation, the deductive method, scientific hypothesis—are altogether passed by, or only just referred to. In fact, Dr. Venn's volume, which he tells us embodies the substance of courses of lectures, must be regarded as a series of discussions of some of the more important or more neglected points of logic, having a certain connection from the fact that they imply one *manière de voir*, and the same fundamental principles. This being so, one must try to indicate the quality of the work by a reference to one or two of the more important matters dealt with.

To begin with the first chapter, which is an excellent compact statement of the main pre-suppositions of material logic, Dr. Venn has done good service in showing how much work of the mind has gone to the construction of the world of objects with which the logician sets out. All that he says here about the work of analysis and synthesis might perhaps be translated by a Kantian or even a Hegelian into his own philosophical dialect. What our author, however, is concerned to bring out is the practical motive that underlies our common thought-distinctions. He shows in a striking manner that there is something arbitrary in our way of demarcating "things" or "objects," though this is justified by practical exigencies. The recognition of this elasticity in our conception of a thing enables the writer later on to handle with good effect the common distinction between concrete and abstract terms. These, says our author, are not absolute, but relative designations. "Hardly any object, as objects are regarded by us, can be selected, which is not to some extent a product of our powers of abstraction, and the more or less of this faculty called into play in any particular case hardly warrants us in labelling the instances respectively with such distinct designations."

Somewhat similar considerations are applied to collective terms. "There is nothing," writes Dr. Venn in his most ingenious vein, "to hinder us from taking a 'scratch lot' of things, to use the slang phrase, and giving a name to the lot with the caprice which we show in naming a yacht or a dog," *e.g.* the persons who happen at a particular moment to be in a given space in Fleet Street. This idea of the arbitrary limits of our common distinctions is made good use of in the treatment of the relation of the subject and predicate in propositions where, as too rarely happens in English works on logic, adequate recognition is taken of impersonal propositions. With reference to this last topic, however, it should be said that Dr. Venn's treatment, though fresh and suggestive, is hardly adequate. He seems to start from the supposition that logicians resolve all forms of predication into attribution of qualities to things (the subjects). This is to ignore the careful analysis of the import of propositions carried out by Mill, Bain, and others.

In a work on inductive logic the mode of dealing with causation may be said to be conclusive as to the writer's competence. Dr. Venn's account forms one of the most valuable portions of his work. Very happy and fruitful in simplification and the dispelling of confusion is his idea that the logician in dealing with the relation of cause and effect stands midway between the point of view of every-day practical sense and that of a rigorously scientific or speculative intelligence. The popular view is practical, and is subordinated to the production of (desirable) effects. The logician improves on this, first of all by enumerating the antecedents more completely, and secondly by "screwing up the cause and effect into close juxtaposition,"—that is, into an approximately immediate sequence. At the same time, he does not aim at absolute completeness in either respect, for this, as the writer shows, would be to defeat his end. He retains something of the popular practicality of view, and this is ingeniously illustrated in the common logical doctrine that, whereas the same antecedent can only be followed by one consequent, the same consequent can be preceded by different antecedents (plurality of causes). Perhaps Dr. Venn is a little hard on Mill and logicians generally for their way of formulating the causal relation. No doubt, as he contends, every concrete event is a highly complex group of elements, followed by another complex group. But the logician is dealing with causation for purposes of induction. He assumes that the investigator must generalize, and generalize as far possible, if he wishes to attain his goal, viz. comprehensive principles or laws. A general statement, such as "Friction produces heat," is, no doubt, in a sense highly elliptical. There must of course be, in every case, a definite set of circumstances in which the friction acts and the heat is developed. But there is no need to refer to these in stating the general truth; on the contrary, this statement, just because it is a large principle available for guidance in a vast number of diverse cases, must be an abstraction. Historically considered, moreover, it may be said that Dr. Venn makes too much of the practical impulse in the genesis of our idea of causation. Primitive man, as soon as he could form an idea about cause at all, was presumably already beginning to ask about the origin of things, and to work out a crude cosmogony of his own.

On the nature of inductive processes, and the well-known methods formulated by Mill, our author is distinctly in advance of his predecessors. With his customary caution he points out the difficulties that have to be got over before generalization can begin. Combining in a manner the views of Mill, Whewell, and Jevons, he regards a complete process of inductive discovery as consisting of three steps, viz. (1) a stroke of insight or creative genius in order to detect the property to be generalized (and possibly also the class); (2) the formal process of generalization; and (3) the final stage of verification (apparently by way of deduction). The chapter on the methods is judiciously critical, and may with advantage be compared with Mr. Bradley's less discriminating treatment. The way is prepared for a study of the complex problems of physical induction by the selection of a simple artificial example, viz. the case of a man in an hotel office, who has to determine what room rings a particular bell. This case is dealt with by purely formal considerations, similar to those which guide us in the problems of symbolic logic. It is then shown that such purely formal treatment is inappropriate in the case of physical investigations, and the special methods of induction are thus introduced as a *pis aller*. The author is most original in dealing with the Joint Method, which every careful reader of Mill's "Logic" must have felt was very far from clear.

There are other features in Dr. Venn's scheme of induction which deserve careful notice. Among these may be named the account of co-existences as distinguished from sequences (chapter iii.); the description of the nature and function of units and standards (chapters xviii. and xix.), which is less technical and more suitable to a logical treatise than that given by Jevons; the highly characteristic chapter on the possible extension of our general powers of observation (chapter xxiii.), where the bold idea is entertained of our being able some day to spread out an event in time just as the telescope and the microscope enable us to spread out an object in space; and, lastly, the discussion in the concluding chapter of the effect of our practical tendencies in modifying a strictly logical or speculative view of the world.

Any one of these might well call for detailed remark if space permitted. They show the author at his best, finely observant of overlooked points, subtly ingenious in devising new, quaint, and even startling possibilities. But the reader must be referred to the volume itself for a fuller appreciation of these qualities.

When one has gained much pleasure and profit from a work, it seems almost shabby to begin to find fault. Yet no critical reader of Dr. Venn's treatise can fail to perceive its defects. It is as if the author had boldly set them before our very eyes challenging criticism. The want of close connection has already been touched on. There seems, indeed, a surprising lack of systematic arrangement, as if the author had sat down to write without a clear plan before him. Poor formal logic gets badly treated. Thus we have an account of terms, propositions, including hypotheticals and disjunctives, but no account of the syllogism. Nor can it be said that the writer has introduced just as much of the common syllogistic logic as is needed for setting forth the processes of induction. Much given us under terms and propositions cannot well be regarded as needed in a treatise on the logic of induction. Sometimes, indeed, the author wanders into the mystic region of symbolic logic. Again and again he opens up in a tantalizing way views which he does not stop to establish. One may instance the point touched on (p. 43), whether the converse of a particular proposition is in substance a new proposition. This depends on our view of the import of a proposition, which, as already pointed out, is not adequately dealt with. Again, the author seems to deny the existence of a negative disjunctive of the type "Either A is not B or C is not D," but he does not trouble to prove the point, or indeed to make clear what he precisely means. It is surprising, again, to find Dr. Venn discussing the functions of the syllogism not only without giving any preliminary sketch of it, but without the barest reference to the nature of the axiom which underlies it. On the other hand, a good deal that is known to the general student from previous works (including the author's own) is needlessly repeated, and helps sadly to swell the size of the volume. Another feature that will strike every careful reader, and which is strongly suggestive of defective plan, is the frequency of the forward reference, as "we shall see by and by," and so forth. This is apt to be very confusing. In noting this, together with the comparative infrequency of the backward reference, one cannot help thinking of the author's remark on the popular view of causation, that it looks forward rather than backward.

A number of the author's statements seem to the present writer open to dispute. It must be surely a slip which makes him write of the classifications of natural history as made up of *collective* terms (p. 170). The Dicotyledons are surely not a collection in the sense in which the House of Commons is a collection. The limitation of the denotation of terms to present existences (p. 179) strikes one not only as highly capricious, but as inconsistent with what is said about differences of time in connection with predication. Once more, one would like to challenge the strong statement that the only easily discoverable instance of a purely verbal dispute is that about the "sameness" of a thing (p. 296). In one place, at least, the writer's ingenuity seems to carry him too far. Writing of logical definition by genus and differentia (p. 302, by a slip written genus and species), Dr. Venn tries to show that this is perfectly rational on the supposition (which logic is bound to make) that we all know the meaning of our terms, or, since the very need of defining a term shows that there is one term of which this cannot be supposed, of all terms but one. But it is obvious that this consideration would equally suggest or justify an inverse process of definition, viz. by naming a lower species, and subducting its differentia. Such slight blemishes as these are probably inseparable from Dr. Venn's manner of work, and it can safely be said that they detract but little from the general and lasting impression of masterful competence which his volume is certain to leave on the student's mind.

JAMES SULLY.

REMSEN'S "INORGANIC CHEMISTRY."

Inorganic Chemistry. By Ira Remsen, Professor of Chemistry in the Johns Hopkins University. (London: Macmillan and Co., 1889.)

THIS book is of interest from the circumstance that it is the first of its kind in the language of any pretensions which is based upon the periodic law. It is further characterized by the fulness with which general relations are discussed. The attempt is made to present the facts of inorganic chemistry in such a manner as to bring out their analogies and connections, with a view of elucidating the broad general principles of the science. Details of experiments, either as showing the origin and modes of preparation of products, or as illustrating their leading properties, are for the most part omitted, or are relegated to an appendix containing special directions for laboratory work. The book is put together in a plain, straightforward manner, with no attempt at any literary airs and graces; indeed, we may add that at times the style verges on a simplicity which is perilously near being puerile. Having said this much in commendation of the general plan of the work, we have said all we can say in its praise. For, however excellent may be the plan of a treatise of chemistry, its main value, after all, must depend upon the accuracy and completeness of its statements; and, as we proceed to show, there is much in this book which is both inaccurate and incomplete. From the style in which it is issued, and its price, we presume that the work is intended for the benefit of comparatively advanced students —at all events for a higher grade than that for which the author's well-known smaller books were prepared. Indeed, we are distinctly informed that the earlier works were intended to form a series of which the present volume is the most advanced member. Now, whilst it may be convenient for the purpose of elementary teaching not to tell the whole of what is known about a thing, the advanced student, if he has any scientific instinct at all, insists on knowing the truth, the whole truth, and nothing but the truth. Unfortunately, he does not always get that from this work. Prof. Remsen is admirable in his introductory books. In these there is a reticence of statement and a subordination of facts which make the books excellent for the purposes of school-teaching. But in the larger book it appears to us that the author suffers from the defects of his excellencies: what is a merit in the "Briefer Courses" becomes a positive blemish in the advanced work. Indeed, the volume before us seems to be nothing but the smaller work on inorganic chemistry "writ large," since in point of knowledge the student is not carried very much further than he is in that book. Take, for example, the statement respecting the mode of preparing hydrogen, given on pp. 26 and 27. We read that, when sulphuric acid acts upon zinc, the chemical change is represented both qualitatively and quantitatively by the equation $Zn + H_2SO_4 = ZnSO_4 + 2H$. This is stated without a word of qualification, in a long paragraph on the complex nature of the changes which take place in a chemical reaction; and yet every teacher knows that this equation does not express the truth, the whole truth, and nothing but the truth about the matter. Again, too, on p. 30, in the account of the mode of preparing oxygen, we have the conventional methods of representing the decomposition of potassium chlorate into equal parts of perchlorate and chloride, and the subsequent decomposition of the perchlorate into chloride, whereas Teed, and, subsequently, Frankland and Dingwall, showed some years ago that these equations altogether fail to represent what actually occurs.

McLeod's work on the part played by the admixed manganese dioxide in facilitating the evolution of oxygen from potassium chlorate is perhaps too recent to have received notice in the very meagre account given of the supposed modes of action of this substance; but the space occupied by the description of "gnomium," which is still more recent, might, we think, have been more profitably employed by some mention of Mercer's theory of "catalysis." This poverty of statement is, at times, almost exasperating. The account of Lavoisier's work, on p. 5, would have seriously jeopardized the chances of a London University matriculant if given in an examination paper. Nine out of ten average students would gather from this account that Lavoisier made chemistry what it is to-day by proving why it was that, "whenever water is boiled for a time in a glass vessel, a deposit of earthy matter is formed." With respect to the etymology of the term oxygen, it is stated that "the name is at present somewhat misleading," which might imply that it may possibly become less so in the future. On p. 298 we are told that "it was in an examination of urine for the purpose of discovering the philosopher's stone that phosphorus was first discovered in 1669." On p. 383 it is stated that "the name soda-water had its origin in the fact that the carbon dioxide used in charging the water is frequently made from primary or acid sodium carbonate." Are we to infer also that lithia and potash waters are prepared from carbonic acid evolved from the carbonate of the respective metals? On p. 141 we read that Lavoisier "considered chlorine to be an oxygen compound of some undiscovered element which was called *murium*. . . . The acid was accordingly called *muriatic acid*. . . ." If this implies that the term "muriatic acid" was derived from *murium*, it is contrary to Lavoisier's own account of the origin of the name. On pp. 60 and 61 of his "Traité Élémentaire de Chimie," partie 1, chap. iii. ("Œuvres de Lavoisier," Imprimerie Impériale), "De la Nomenclature des Acides en général, et particulièrement de ceux tirés du salpêtre et du sel marin," he says:—

"Rien ne nous a été plus facile que de corriger et de modifier l'ancien langage à l'égard de ces acides; nous avons converti le nom d'acide vitriolique en celui d'acide sulphurique, et celui d'air fixe en celui d'acide carbonique; mais il ne nous a pas été possible de suivre le même plan à l'égard des acides dont la base nous était inconnue. Nous nous sommes trouvés alors forcés de prendre une marche inverse, et, au lieu de conclure le nom de l'acide de celui de la base, nous avons nommé, au contraire, la base d'après la dénomination de l'acide. C'est ce qui nous est arrivé pour l'acide qu'on retire du sel marin ou sel de cuisine. . . . Nous avons nommé cette base inconnue *base muriatique*, *radical muriatique*, en empruntant ce nom, à l'exemple de M. Bergman et de M. de Morveau, du mot latin *muria*, donné anciennement au sel marin."

And in the index it is given: "*Acide muriatique*—son nom dérivé du mot latin *muria*, 61." As a matter of fact, the term was employed by Bergman and Scheele some years before the Lavoisieran nomenclature was published.

Loose, imperfect, or partial statements are, in fact, to be found on every other page. The word *eudiometer* is derived from εὔδια, calm air, and μετρον, a measure, "because it is used for the purpose of measuring gases (p. 51)." On p. 61, dissociation is defined to be "the gradual decomposition of a chemical compound by heat." Contrary to the statement on p. 44, hydrogen has *not* been liquefied. If this gas does not unite with oxygen at ordinary temperatures (p. 45), how is the action of platinum foil and of the Döbereiner lamp explained? The well-known process of extracting silver from argentiferous lead is called *Pattison's* method (p. 598). On p. 304 it is stated that phosphine unites with hydrochloric acid to form phosphonium chloride, and the statement is made that the reaction is perfectly analogous to that which takes place between hydrochloric acid and ammonia. It is nothing of the kind: phosphine and hydrochloric acid only combine under pressure, and the compound is dissociated, at ordinary temperatures, when the pressure is released. To judge from the statement on p. 281, the author is ignorant of the work of Tilden on the oxychlorides of nitrogen. The rusting of iron (p. 693) is *not* due to moisture in the air: iron does not rust in moist air in the absence of carbonic acid, as every tin-plate worker knows, and as Crace-Calvert, years ago, conclusively demonstrated. On p. 121 we have an account of chlorine trioxide, although Garzarolli-Thurnlackh, more than eight years since, working under Pebal's direction, showed that the substance so designated is a mixture of the dioxide with varying quantities of free chlorine and oxygen. The author still believes, apparently, in the existence of the ammonium-amalgam, and wholly ignores the work which shows that it is nothing but a metallic froth. He incorrectly describes the action of sulphuric acid upon potassium permanganate (p. 683), and tells us that no oxygen compound of fluorine is known, in spite of the existence of an oxyfluoride of phosphorus. The argument as to the valency of fluorine and the constitution of fluosilicic acid (p. 416), based on the supposition that hydrofluoric acid has the molecular formula H_2F_2, falls to the ground in view of the recent work of Thorpe and Hambly. These by no means exhaust all the errors we had noted, but the list is sufficiently long to show that the book has apparently been hastily and somewhat carelessly put together. It has, however, certain good points, and by a judicious overhauling might be made into a good book, for it is precisely one of those works that would have been better if the author had taken more pains.

THE MIDDLE LIAS OF NORTHAMPTONSHIRE.

The Middle Lias of Northamptonshire. By Beeby Thompson, F.G.S., F.C.S. Pp. 150. (London: Simpkin, Marshall, and Co., 1889.)

THE sub-title of this work explains that the subject is considered stratigraphically, palæontologically, economically, as a source of water supply, and as a mitigator of floods.

The author commences with some account of the beds grouped as Middle Lias, there being considerable difference in the classifications adopted by geologists, from the fact that the distinction between Middle and Lower Lias is mainly dependent on fossils. In considering this matter we have to deal with a series of clays, exhibiting a succession of organic remains, intimately connected, and yet characterized at different horizons by certain species of Ammonites. There are no stratigraphical planes of demarcation for our guidance, and it is merely a matter of convenience (or inconvenience as the case may be) to adopt a divisional line. The subject was discussed at some length in NATURE (vol. xv. p. 113) and we may therefore pass on to say that Mr. Thompson includes in his Middle Lias the zones of *Ammonites margaritatus* and *A. spinatus*, in this respect following the plan adopted by the Geological Survey.

As with the junction of the Middle and Lower Lias, so with that of the Middle and Upper Lias, there is, at any rate in Northamptonshire, evidence of intimate connection. We find, in fact, a "transition bed" between Middle and Upper Lias; and this, although but a few inches thick, has furnished a large number of fossils to Mr. T. Beesley, Mr. E. A. Walford, and the author of this work. Much interest attaches to this transition bed, from the fact that it contains an admixture of Middle and Upper Lias fossils, although a larger proportion of the former. Among the Upper Lias Ammonites found in it are *A. communis*, *A. annulatus*, and *A. Holandrei*; and it is noteworthy that *A. communis* and *A. crassus* are recorded also from the Marlstone below (zone of *A. spinatus*). All these species are very closely connected, and the abundance of *A. communis* in the lower beds of the Upper Lias of some parts of England, serves to show that its value as a zonal species in the uppermost beds is very local. We note that Mr. Thompson speaks of "falcifer" Ammonites—a mode of expression with which we fully sympathize, for the species, unfortunately, are becoming so much subdivided that before long no one but a specialist in Ammonites will dare to identify any particular form.

The work before us well illustrates the progress made in our knowledge of the details of British formations. The author has evidently laboured long and earnestly at his subject, and indeed no one but a resident geologist could have given us such particulars of the subdivisions of the Middle Lias and the fossils that occur in the different layers, for some sections yielding valuable information are open but for a short time, and the geologist who spends but a few weeks in a district may fail to find exposures of every zone. Moreover, now increasing attention is given to the biological history of species, the precise position they occupy in the series of strata is of the greatest importance. Hence the work is of value not merely from a local point of view, but as contributing much material that will help towards a full knowledge of the Lias of Britain.

Summarizing his results, Mr. Thompson catalogues 94 genera and 273 species from the Middle Lias, including, however, but few of the Foraminifera. Vertebrate remains are scarce, but the conditions of deposit, as remarked by the author, were to a large extent shallow water and littoral marine—conditions that appear to be generally unfavourable to the preservation of the fishes and reptiles of the Lias.

The economic products of the Middle Lias are duly noted by the author. These are practically confined to building-stone and brick earth. The valuable iron ores found in some localities hardly come into the area, although some beds were at one time worked at King's Sutton.

Considerable attention has been given by the author to the question of water-supply, and in 1881 he suggested that the supply for the town of Northampton might be increased by the formation of a number of dumb-wells. In this way he anticipated that the surface drainage might be conducted underground through the Upper Lias, so that the porous beds of the Middle Lias would be utilized as a natural reservoir, while at the same time the liability to floods would be lessened. The scheme was brought before the Town Council, but, as the author candidly admits, the Water Committee, after consulting Sir Robert Rawlinson, were fully justified in rejecting it. It is, however, far from apparent that the scheme was faulty in theory. The natural storage of water has been advocated by several authorities, and it has been put into practice in India. The whole subject is worthy of close attention, and we can commend this portion of Mr. Thompson's book to those interested in the questions of water-supply and drainage. H. B. W.

OUR BOOK SHELF.

A Dictionary of Explosives. By Major J. P. Cundill, R.A. Published by the Royal Engineers Institute. (Chatham: Mackay and Co., 1889.)

IT is impossible to look at this list of explosive substances prepared by Major Cundill without coming to the conclusion that the chemist has had little to do with the most of them. Mixtures are things which do not delight the chemical mind either in an explosive substance or anything else. It places too much reliance on some mechanical operation, mixing or something of that kind, to give the chemical notion of exactness in its composition.

A theoretically perfect explosive would be a substance like hexanitro-benzene, $C_6(NO_2)_6$, but this has not yet been made. The variety and curious nature of substances and mixtures, many of them solemnly patented, described in this book, are most interesting. One, amongst several, is a mixture of carbonate of lime, chloride of sodium, and urine evaporated with charcoal. It seems pretty harmless as an explosive. Not so, however, many other mixtures containing potassium chlorate for which safety is claimed. It is really quite incomprehensible how people with the slightest knowledge of chemistry can propose mixtures containing potassium chlorate and organic substances, and in many cases even sulphur as well.

By drawing the attention of chemists to the amount of nonsense palmed off on the Patent Office, this little book will se ve a good turn; but it is also of practical value, as extracts from the specifications are given in many cases which may save much seeking.

Some advice at the end of the book is useful, especially to those interested in explosives in a professional way, but who are not sufficiently chemists to be able to deduce it for themselves. Possibly it is the fault of the specifications, and not the author, that benzene is written in several ways, benzole, benzine, &c.

On p. 68 there is an equation to represent the products of gun-cotton when detonated, to which perhaps some exception may be taken, but after all but slightly, for there is still much ignorance on the matter. It is

$$2C_6H_7O_2 3NO_3 = 9CO + 3CO_2 + 7H_2O + N_6.$$

It is very doubtful indeed whether any of these nitrates can be burnt under any conditions without yielding a considerable quantity of oxides of nitrogen as end products; probably NO in the first instance, which takes up oxygen from the air, and is undoubtedly the greatest drawback in the use of gun-cotton, glycerol nitrate, and similar substances.

Some advice is given about nitro-glycerine on p. 39. "Any indication of acid fumes or tinge of green should be followed by their prompt destruction with suitable precautions." It would have been well here to give some precautions even at the risk of repetition, for it is not safe to play with nitro-glycerine when in this state. The author might have added that an addition of aniline at this stage renders the destructive operations much safer.

Under the heading of smokeless and "noiseless" gunpowder, little more could be said at the present time than the author has ventured upon. We do not quite believe that a "noiseless" explosive will be so easily found as a smokeless one. Such a substance belongs almost to the category of explosives that act in "one direction only," or have no recoil.

We think the book will be useful in several ways. Blank pages are inserted for further additions to our stock of explosives, safe and unsafe, as they are published.

W. R. H.

Gaseous Fuel. By B. H. Thwaite. (London: Whittaker and Co., 1889.)

THIS little book of forty-six pages contains the substance of a popular lecture delivered by the author, under the auspices of the Manchester and Salford Noxious Vapours Abatement Association. It gives an account of the principles which underlie the economical consumption of fuel in general, and of the various forms of "gaseous fuel" in particular, and more especially of those forms in which the lecturer is professionally interested. The book, of course, makes no pretensions to deal with the subject exhaustively: its main object, apparently, is to direct attention to the advantages of smokeless fuel as compared with coal as ordinarily burnt. The author is occasionally to be found tripping in his chemistry and physics, and there are, now and then, a few awkward turns of expression. Thus, we read that fire-damp "is a light carburetted hydrogen, one of the gaseous paraffines or methane, its principal formula being chiefly CH_4"! (p. 15). The inventor of the well-known laboratory burner is styled "Baron Bunsen." On p. 34 we read: "The principle of the development of motive power by the instantaneous combustion of gaseous fuel rests in the laws of Charles Gay Lussac and Boyle—*ergo*, that the pressure exerted by a gas varies directly as its volume." The author seems to imply that the idea of using the fire-damp at Hebburn Colliery, near Newcastle, originated in a suggestion made by him some two years ago in *Engineering*. In reality, the idea is due to the younger Buddle. Indeed, as a matter of fact, blowers which have been encountered in the process of working have been frequently utilized either for heating or illuminating purposes; notable examples are at Llwynypia and at Pandy, in the Rhondda Valley.

A Treatise on Spherical Trigonometry, and its Application to Geodesy and Astronomy. With Numerous Examples. By Dr. J. Casey, F.R.S. (London: Longmans, 1889.)

THIS is a sequel to the large "Plane Trigonometry" by the same writer, and is naturally drawn up on the same plan. Its size is handy, and yet it contains a very large amount of matter. Much of this the author claims to be original, and a great deal, as in the case of the "Plane Trigonometry," has been collected from the foreign mathematical journals. The first three chapters cover familiar ground, with here and there a new feature inserted. Chapter iv., entitled "Various Applications," gives properties of transversals, of isotomic and isogonal conjugates, of the Lemoine and symmedian points, and of some other lines with which recent plane geometry has made us familiar—more especially our author's own "Sequel to Euclid." Chapter v. discusses the spherical excess, and in chapter vi. we have a full account of small circles on the sphere. The subject of inversions is discussed in chapter vii., and in chapter viii. we have full details of the polyhedra. The last chapter gives an account of numerous applications of the subject, as to geodesy and astronomy. It would be almost impossible, we should say, to light upon a theorem elsewhere which is not contained here. More than 500 exercises afford scope for practice. As in the case of the "Plane Trigonometry," the author's great indebtedness to Prof. Neuberg, of Liége, is suitably acknowledged, for it is through this gentleman's courtesy the book is brought so thoroughly into touch with Continental sources of information.

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.*]

Coronæ round a Light produced by a Peculiar St ucture in the Eye.

FOR some years past I have been aware that a bright light on a dark background appeared to be surrounded by faint coloured rings, and that these rings were due to something in the eye itself. But I gave them little attention, for I imagined they were formed in the same way as the coronæ seen when the sun or moon is covered by a thin cloud; opaque particles in the cornea, or little elevations or depressions of its surface, playing the part of the drops of water in the cloud. This is the view taken in Verdet's great work on the wave-theory of light. "Les cercles irisés, qu'à la suite de certaines inflammations de la conjonctive on aperçoit autour des corps lumineux, se rattachent à la même cause que les couronnes; ces apparences sont dues à l'existence de granulations très-petites et sensiblement égales dans la portion de la conjonctive qui se trouve en avant de la cornée transparente" (Verdet, "Leçons d'Optique Physique," § 79). I have lately discovered, however, that the phenomenon in my own case must be due to quite a different cause.

A leading characteristic of the diffraction phenomena produced by a number of equal obstacles, *irregularly spaced*, is the bright disk surrounding the light, which is for the most part nearly white. Near the light it is bluish, while the outer border passes through yellow to red. To the red succeeds purple, blue, green, yellow, red, &c., the colours resembling those of Newton's rings. The central disk is far the brightest part, and there is no real break in the colours, though the first purple is a good deal darker than its neighbours. The easiest way to see these colours is to sprinkle a slip of glass with Lycopodium seed and look through it at a bright point of light. The above description applies equally well whether the obstacles are spherical or cylindrical. The latter form is nearly approached in Nature by the fine needles of ice of which many clouds must be largely composed. With other forms of obstacle the colours would be more or less blurred, but in any case the bright central disk would survive.

When recently engaged in investigating such phenomena, I noticed that the rings formed in my eye were of an utterly different character. There are two narrow rings, apparently in contact—the inner green, the outer red; the apparent breadth of each being about 20′, and the radius of the intermediate circle about 2° 30′. Within the green ring is a broad dark space, and then comes the ordinary colourless haze surrounding the light. The rings are not quite continuous, and certain short arcs are much brighter than the rest. But the arrangement of these arcs seems quite irregular, and is different in the two eyes. With this exception the two eyes behave alike. The green and red, though faint, are of good quality, not unlike a very faint prismatic spectrum. They are rather capricious in their appearance, requiring a dark background and a moderately bright light. A small arc light some thirty yards from my window generally shows them well, though they vary a good deal in brightness, and at times I cannot see them at all.

The question was, how the colours were produced. After pondering the matter for some time, and rejecting one explanation after another, the true solution suddenly flashed upon me. The colours are the first spectrum of a diffraction grating, and the ring form is due to the bars of the grating lying in different directions in different parts of the eye. The idea was readily put to the test. Cutting a small hole, one-tenth of an inch square, in a piece of paper, I held it in front of the eye. When the aperture was in the centre, the coloured rings vanished; when it was drawn to one side to the very edge of the pupil, two bright spots appeared on the circle, one above, the other below the light. The rest of the circle was invisible. As the aperture was moved round the outside of the pupil, the two bright spots revolved round the circle, preserving their angular distance of 90° from the aperture. This shows that the bars of the grating radiate from the centre of the pupil and are only found near its edge. From the dimensions of the rings we may deduce that the lines are spaced at the rate of about 75 to the millimetre, or 1900 to the inch. Since the coloured ring is not uniformly bright, the grating must be imperfectly developed behind some parts of the outer edge of the pupil. But trial with the diaphragm left no doubt that the structure was present to some extent all round. I then compared the coloured rings with the spectra seen on looking at a light through an ordinary diffraction grating of 3000 lines to the inch. The appearance was very similar, though in the latter case of course the red and green were much brighter, and were accompanied by a comparatively faint violet band. The breadth of the red and green bands relatively to their distance from the light agreed very well with the measurements given above.

Another evening I prepared some diaphragms with annular apertures of which three, A, B, C, had the inner and outer diameters respectively 10·7 and 8·6 mm., 9·9 and 7·6 mm., 8·1 and 6·1 mm. In A the central stop was large enough to hide the light and of course extinguish the rings too. With B when held centrically the rings were very plain—indeed yellow could be made out between the green and red—while the light was distorted and enlarged by both spherical and chromatic aberration. With C the rings were visible but not distinct. I found too that with B I could see the rings round the naked flame of a bright paraffin lamp only two or three feet away, for the pupil enlarged till it cleared the stop. But with C, I had to move two or three yards away before the rings appeared. These experiments show the diffracting structure to exist in a ring, whose diameter lies between 8·1 mm. and 7·6 mm., and that it does not extend far inside the lower limit. Further, the diameter of the pupil when the rings are visible may be decidedly less than 8·6 mm. The structure is not on the inner edge of the iris, but it may lie either in the cornea or in the crystalline lens. The latter is known to be built up of closely-packed radial fibres from 0·0056 mm. to 0·0112 mm. in breadth (Helmholtz, "Physiologische Optik," § 5). It seems probable that some modification of these near the edge of the lens form the diffracting layer. I have since found that at a distance of a hundred yards from the electric light the pupil can be made to clear the central stop of A. There is then seen a narrow circle of light, too faint to show colour. I was not able to get a good enough measure of its diameter to decide whether it was smaller than before.

I can hardly fancy this curious structure in the eye to be a rare peculiarity. One of my friends saw the green ring well defined round the electric light one evening, and with practically the same radius as I. He was not sure about the red. Inside the green he described the colour as very dark purple, almost black. Probably this was a contrast effect, but possibly it was the violet of the spectrum. In Sir John Herschel's "Meteorology" I find the following passage. After speaking of coronæ round the sun, he says: "Occasionally the cornea of the eye itself becomes filmy by the diffusion over it of minute particles, which (such at least is our personal experience) exhibit round a candle two or three beautiful coronas, the second of 17° 57′ in diameter, of vivid colours and most perfect definition." This description makes me feel suspicious that the rings were of the same class as mine. It suggests separate spectra such as are produced by a diffraction grating. Further, the accuracy of the measurement implies a tolerably narrow ring, whereas in ordinary coronæ, if the second green had a diameter 18°, the second blue and second red would have diameters 15° and 23° respectively. His dimensions do not agree with mine, but imply bars or lines at distances of about 0·007 mm. Fibres of this breadth are found in the crystalline lens. JAMES C. MCCONNEL.

Davos, Switzerland.

Use or Abuse of Empirical Formulæ, and of Differentiation, by Chemists.

As I believe that I am one of the "ingenious and clear-sighted" chemists who, Prof. Lodge suggests, may be "run away with by a smattering of quasi-mathematics and an over-pressing of empirical formulæ," I hasten to assure him that he is quite wrong in his surmises.

With every word of Prof. Lodge's remarks on the proper method of examining curves I heartily agree; with his strictures on the abuse of formulæ I more than agree: I should advise chemists not even to use them.

The method of examining the continuity of any curve by plotting out the experiments themselves, and then differentiating the curves representing them, is the method which I have applied in nearly every case, and applied it, I believe, for the first time to questions of a chemical nature. The only difference between my *modus operandi* and that which Prof. Lodge suggests is that, instead of differentiating the curves by a mechanical integrator, I take readings from them at definite intervals, and find the differences between these readings arithmetically.

I do not consider, however, that this is the safest method of examining results. The method which was introduced to the notice of chemists by Mendeleeff, which was used subsequently by Crompton, and on which I have placed my chief reliance, consists of differentiating the experimental numbers themselves, and not the curves which may be drawn to represent them. If s_1 and s_2 be the densities of p_1 and p_2 per cent. solutions, $\frac{dp}{ds}$ at a percentage $\frac{p_1 + p_2}{2}$ is given by $\frac{s_1 - s_2}{p_1 - p_2}$.

Each of these two methods has its own special advantages, but the balance is generally strongly in favour of the last one. It does not necessitate the drawing of the original curve, which drawing may often be considerably modified by the "taste" of the drawer; it will sometimes bring about the recognition of breaks which might be overlooked in the original curve, for though the differential curve can show no breaks which do not exist in the original curve, it may often, as a consequence of its very nature, show breaks clearly, which would be recognized only with difficulty in the original curve; and, lastly, the proper depiction of the original curve is often a practical impossibility, as, for instance, with the densities of sulphuric acid solutions, where the scale which would have to be adopted to give the experimental error a fairly visible magnitude would involve dealing with a curve some 3000 inches long.

Prof. Lodge could, no doubt, have told us more than he has done of the difficulties and dangers of differentiation in any form, and, perhaps, the extensive practical experience which I have had in the process has made me more alive to these dangers than even he is. I need only say here that I have not yet come across a case where I should feel warranted in stating that a break existed on the evidence of one curve only where the break depended on differentiation for being clearly visible. In my own work I have never considered any breaks as being more than "suggested" unless they were shown by at least two different properties of the substance under examination; the majority of the breaks which I insist on are shown by more than two, in some cases by as many as seven different properties.

As to the examination of the curves by means of empirical formulæ, nothing of the sort has been done, and it is difficult to understand how Prof. Lodge, even though he speaks under correction, should have so misunderstood the methods adopted. If Mendeleeff's paper may have been open to misinterpretation, Crompton's certainly was not, for he gives in a tabular form the results of the direct differentiation of the experimental numbers themselves; an abstract only of my own paper has as yet appeared, and I have not got it by me to refer to, but I do not think that the terms "formula" or "equation" occurred throughout it. The impossibility that seems to exist of getting either chemists or physicists to understand that the method of examining curves which we have employed does *not* involve the use of any equation at all is indeed extraordinary. My own opinion on the use of equations will be best illustrated by the following extract from my paper:—"It is necessary to say a word at starting to correct an erroneous opinion which is prevalent as to the method of examining curves which I have adopted. . . . It is imagined by many that this method consists in fitting sundry equations to the curves, and, on the strength of their concordance with these equations, to conclude that they are continuous or otherwise. Now, it is quite true that if a curve differentiates into a straight line after a certain number of differentiations, an equation of a certain form must represent that curve, and if it yields several straight lines there must be as many different equations applicable to different parts of it; but it is one thing to find equations empirically, and prove (?) their truth by a display of those most fallacious of arguments known as tables of 'found' and 'calculated' values, and another thing to apply an ordinary process of mathematical analysis to the curves, letting them speak for themselves, and tell us whether they are continuous or not. On the former of these methods I would place absolutely no reliance, and so far have I been from making use of it, that I have not found the equation for any single curve here depicted, and have purposely avoided finding any. The mathematical argument on which this work depends is, that a curve, if it be continuous, will on differentiation give either a straight line or another continuous curve, whereas, if it be not continuous, but be made up of different curves, will yield on differentiation a series of straight lines or curves. This, I think, is an incontestable fact."

That the majority of chemists are not mathematicians I willingly admit; this painful fact is shown only too clearly by their blind acceptance as gospel truth of everything which is "proved" mathematically. But Prof. Lodge must do us the justice to admit that we have occasionally some glimmers of common-sense, glimmers which would be inconsistent with our assuming that a certain curve was a parabola, and then being pleased, or even surprised, that it behaved after the manner of parabolas.

However much I may envy the powers of a mathematician, and however firmly I may believe that chemical facts will eventually be translated into mathematical expressions, I feel that at the present day the introduction of mathematical formulæ into chemistry almost invariably involves the exclusion of common sense. It is curious that Prof. Lodge's letter should have been immediately followed by an article on chemical affinity, which, I think, will be found to give a striking illustration of this dictum. What may be termed the x and y theory of chemical action, studied on paper by Guldberg and Waage, and followed up in the laboratory by Ostwald, has led unfortunate chemists into a labyrinth of cumbrous mathematical expressions for erroneous facts, where the common-sense of Berthollet would have given them a simple explanation of all the true facts of the case (see Trans. Chem. Soc., 1889, 26).

Harpenden, July 22. SPENCER PICKERING.

P.S.—Since writing the above I have obtained the most absolute justification of my method of differentiation which could possibly be obtained. I have isolated in the solid crystalline form a new hydrate of sulphuric acid, the existence of which I had predicted from an examination of the density and heat results of solutions of the acid. A few further details on the subject will, I believe, be found in the last issue of the *Chemical News*. S. P.

Ilfracombe, August 4.

PHOTOGRAPHIC STAR-GAUGING.

THE mere equal-surface counting of the stars visible with the same instrument in different sections of the sky gives results open to misinterpretation. Admirable in itself, the method fails because it encounters what we may call "systematic errors" in the distribution of the stars. With incidental anomalies it is fully competent to deal; they should, on a large average, be mutually compensatory; but it breaks down before the clustering tendency which pervades, more or less markedly, the entire sidereal system. Not only are certain parts of space more crowded than others, but the crowded parts are related according to an obvious plan. They do *not* occur casually. Their effect is then heightened, instead of being eliminated, by multiplied observations.

The present resources of science, however, seem to offer the means of discriminating, to some extent, between real crowding and the simple extent of star-strewn space. Although the total number of the stars visible in each case with the same telescope might be precisely the same, their relative numbers, counted by magnitudes, would in all probability be very different. In a stratum, supposing the distribution of the stars equable, and their size uniform, their numbers should be nearly quadrupled at each descent of a magnitude. This of course is an ideal law of progression which we cannot expect to find anywhere strictly obeyed; but even approximate conformity to it must be held to indicate with tolerable certainty that the lessening ranks of the stars are, on the whole, at distances from us corresponding with their light. Now it *is* approximately conformed to by the stellar multitude down to about 8·9 magnitude over the general expanse of the sky, as well as over the zone of the Milky Way. But in that zone, stars of the ninth and higher magnitudes very much exceed their due numerical proportions; in other words, they are physically, no less than optically, condensed.

From these circumstances two very important inferences may be derived: first, that the lower margin of the galactic aggregations lies at a distance from us corresponding roughly to the mean distance of a ninth magnitude star, costing light some fourteen hundred years of travel; next, that the aggregated objects are average stars, neither larger nor smaller than those in our nearer neighbourhood. Both conclusions seem inevitable should the facts turn out, on closer investigation, to be as above stated. A regular increase in the numbers of the successive photometric orders of stars, tallying with the increased cubical contents of the successive spheres of which the radii are the theoretical mean distances of those same orders, affords strong, if not demonstrative, evidence of a corresponding real penetration of space.[1] And since the sequence continues unbroken down just to the ninth magnitude, we see that the galactic condensations of ninth magnitude stars cannot be situated nearer to us than their brightness would lead us to suppose—cannot, in other words, be stars on a lower than the ordinary level of lustre.

It is tolerably certain, however, that the denser star-clouds of the Milky Way lie far beyond ninth magnitude distance. The ground for this assertion is not the apparent minuteness of their components, but the singular fact, adverted to by Argelander, that, in the divided Milky Way, running from Cygnus to the Centaur, the

[1] The idea of determining distance by distribution seems to have presented itself to Dr. Gould in 1874. See *American Journal of Science*, vol. viii.

shining branches are nearly on a par with the dark rift separating them as regards the distribution of stars even fainter than the ninth magnitude. The nebulous effect to the eye distinguishing the branches is, then, presumably due to more remote collections. As to the further limits of these, we know as yet nothing, except that Herschel's gauge-numbers left it to be inferred that "thinning-out" had become marked before the attainment of fourteenth magnitude distance. On these, and similar subjects, enlightenment may be hoped for through the judicious use of means already at hand.

For simple star-counts, we have only to substitute star-counts by magnitudes over selected areas of the sky.[1] The relative numbers of the photometric ranks can hardly fail to give highly valuable indications as to real distribution; provided only that the assumption of a general uniformity in the brightness of the stars be valid. Not, it need scarcely be said, of a uniformity such as to preclude any extent of individual variety; all that need be supposed is, that the average size of a star remains constant throughout sidereal space. This hypothesis has far more probability in its favour than any other which could be set up instead of it; though it may receive corrections as our inquiries advance.

The photometric classification of small stars is one of the many branches of sidereal science which will henceforth be prosecuted only with the assistance of the camera. Visual methods are inadequate and insecure. Those by photography, it is true, have also their difficulties, not yet completely vanquished: they will, however, evidently prove manageable. Prof. Pickering is tentatively establishing methods in photographic photometry which will doubtless before long be brought to perfection. They depend mainly upon comparisons of stellar impressions upon any given plate, exposed under known conditions, with standard impressions of standard stars obtained with varied exposures or apertures. For the purpose we have in view, accidental errors of estimation, even if very large in amount, are of no importance. What is essential is, that the integrity of the series should be preserved—that the proportionate change of light from one magnitude to the next should remain invariable from the first term to the last. The realization of this aim, now virtually attained, is one of the most weighty services rendered to astronomy by the sensitive plate.

We may now describe the process of photographic star-gauging. It consists in the enumeration, by magnitudes or half-magnitudes, of the stars down, say, to the fifteenth magnitude, self-pictured from distinctively situated patches of the sky. Each such area should be wide enough to insure the elimination of minor irregularities in distribution; but a single large field would often suffice to show the characteristic grouping of the smaller telescopic stars.

The Milky Way would naturally be the first subject of inquiry; and the comparison of several plates taken in different sections of its course might be expected to yield data of great significance as regards its constitution. From simply calling over the muster-roll by orders of brightness of the stars contained in them, answers may be derived to the following questions:—

(1) How far does the regular sequence of increasing numbers extend? That is, down to what grade of brightness do the stars continue nearly to quadruple with each additional magnitude?

(2) Is the progression interrupted by defect or excess, or by each alternately? In other words, does the stellar system embrace systematic vacancies, as well as systematic groupings?

(3) Supposing an accumulation of stars to set in at a definite stage of space-penetration, where does it stop? Down to what magnitude is the augmented ratio of increase maintained?

(4) Are there symptoms of approaching total exhaustion of the stellar supplies beyond?

These should be found in a concurrent decrease of density with brightness, "density" being understood as the proportion of the numbers present to the space *theoretically* available for stars of a given magnitude. For one of two things seems certain: either the thinning fringe of stars is composed of really small objects interspersed among larger ones; or of average stars at average distances from us, but further and further apart from each other. In the first case, the system ends abruptly; in the second, it is, as it were, shielded by outliers from the absolute void.

Particular attention should be paid to the differences of stellar distribution upon plates of the Milky Way proper, and of the dark aperture between its cloven portions. That this really forms an integral part of the galaxy is shown by the far greater profusion of small stars there than in the general sky at the outer margins of the galactic branches—a fact in itself fatal to the "spiral theory," by which the rift was interpreted as a *chink* of ordinary sky-background left by the interlacing, to the eye, of two great streams of stars, one indefinitely more remote than the other. From photographs we may now hope to learn what is the nature of the distinction between rift and branches—what are the magnitudes, relative numbers, and presumable mean distances, of the clustering stars present in the latter, but absent from the former.

Gauges taken in the neighbourhood of the southern "coal-sack" ought to prove instructive as to the nature of the nebulous stratum out of which it seems as if *scooped*. If the Milky Way be there shallower than elsewhere, a greater uniformity of lustre may be looked for among the stars composing it. No background profusely stored with lessening ranks will come into view, and stars below the average of those grouped in bright masses, representing their genuine companions, will be but scantily present.

Outside the Milky Way, two points suggest themselves as likely to be settled by photographic gauges. Argelander found that the faintest stars in the *Durchmusterung* were everywhere in excess of their due proportion.[1] Even at the galactic pole, their increase, as compared with the class next below, was sextuple instead of quadruple; in the undivided galactic stream it was 9½, in the rift 8½ times. If this semblance of crowding *in all directions* at about the mean distance of a ninth magnitude star be no accident of enumeration, then the Milky Way is only the enhancement of a phenomenon universally present, and the fundamental plan of the sidereal system must be regarded as that of a sphere with superficial condensation intensified in an equatorial ring. The counts, to settle this question, will have to extend over a considerable area.

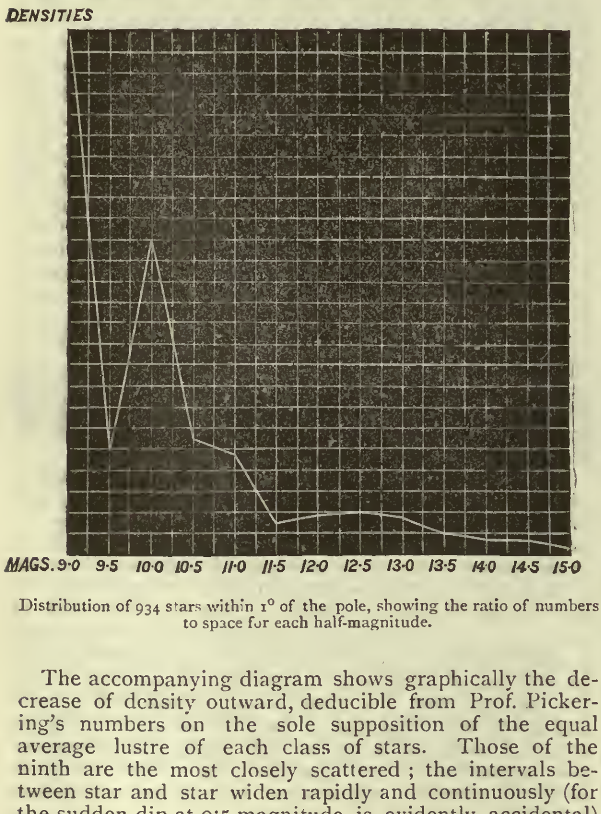
The second point for photographic investigation refers to the limits of the system towards the galactic poles. There is reason to believe them comparatively restricted. M. Celoria, of the Milan Observatory, using a refractor capable at the utmost of showing stars of eleventh magnitude, obtained for a "mean sounding," at the north pole of the Milky Way, almost identically the same number given by Herschel's great reflector.[2] That is to say, *no additional stars were revealed by the larger instrument.* Should this evidence be confirmed, the boundary of the stellar scheme should here be placed at a maximum remoteness of 3500 years of light-travel.

As a specimen of a photographic gauge-field on a small scale, we may take Prof. Pickering's Catalogue, from the Harvard plates, of 947 stars within 1° of the north celes-

[1] This plan was first suggested by Prof. Holden in 1883, as a mode of investigating the composition of star-groupings ("Washburn Publications," vol. ii. p. 113). Counts with varied telescopic apertures gave him the numbers in the successive photometric ranks. We believe that a photographic method of determining them has since been adopted by him.

[1] *Bonner Beobachtungen*, Bd. v. "Einleitung."
[2] *Memorie dell' Istituto Lombardo*, t. xiv. p. 86.

tial pole.[1] The region examined lies about 27° from the zone of the Milky Way, but is nearly reached by a faint extension from it Since only one eighth magnitude star, and none brighter, are included in it, the study of distribution, for which it offers some materials, may be said to begin with the ninth magnitude. A single glance at the synoptical table suffices to show that the numerical representation of the higher magnitudes is inadequate. The small stars are overwhelmingly too few for the space they must occupy if of average brightness; and they are too few in a constantly increasing ratio. Either, then, the diminishing orders form part of a heterogeneous collection of stars of all sizes at nearly the same distance from us (about that corresponding to ninth magnitude); or they belong to attenuated star-layers stretching to a much vaster distance. A criterion might be supplied by Prof. Holden's plan[2] of charting separately stars of successive magnitudes over the same area, and judging of their connection or disconnection by the agreement or disagreement in the forms of their groupings.



Distribution of 934 stars within 1° of the pole, showing the ratio of numbers to space for each half-magnitude.

The accompanying diagram shows graphically the decrease of density outward, deducible from Prof. Pickering's numbers on the sole supposition of the equal average lustre of each class of stars. Those of the ninth are the most closely scattered; the intervals between star and star widen rapidly and continuously (for the sudden dip at 9·5 magnitude is evidently accidental) down to 11·5 magnitude, when a slight recovery, lasting to the thirteenth magnitude, sets in. How far these changes are of a systematic character, can only be decided from far wider surveys. A. M. CLERKE.

TWO AMERICAN INSTITUTIONS.

I.—THE SMITHSONIAN INSTITUTION.

IN 1826, Mr. James Smithson, F.R.S., an English gentleman (a natural son of the first Duke of Northumberland), in a fit of pique at the action of the Committee of the Royal Society, who had declined to accept a scientific paper he had submitted, bequeathed to the United States of America a large sum of money, (£105,000), "to found at Washington under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men."

The question of how knowledge might be best increased and diffused with £105,000 then arose for discussion.

The President of the United States applied to a number of persons, "versed in science and familiar with the subject of public education, for their views as to the mode of disposing of the fund best calculated to meet the intentions of Smithson and be most beneficial to mankind."

The President of Brown University (Prof. Wayland) proposed a University to teach languages, law, and mental philosophy (Arts), without Science. Dr. Thomas Cooper, of South Carolina, proposed a University to teach science only, and to exclude Latin and Greek, literature, law, and medicine. Mr. Richard Rush proposed a Museum with grounds attached sufficient to reproduce seeds and plants for distribution; a press to print lectures, &c., and courses of lectures on physical and moral science, and on government and public law. The Hon. John Quincy Adams proposed the establishment of an astronomical Observatory, with instruments, and a small library. Prof. W. B. Johnson proposed the establishment of an institution for experimental research in physical science. Mr. Charles L. Fleischman proposed the establishment of an agricultural school and farm. The Hon. Asher Robbins proposed a literary and scientific institution; and memorials were presented to Congress in favour of appropriating the fund for annual prizes for the best original essays on the various subjects of the physical sciences; for the establishment of a system of simultaneous meteorological observations throughout the Union; for a National Museum; and for a Library.

For ten years the Congress of the United States wrestled with the interpretation of the words "the increase and diffusion of knowledge among men." The discussions were numerous and irritating; and it was repeatedly proposed to send the money back to England. Finally Congress was wise enough to aknowledge its own ignorance, and authorized a body of men to find some one who knew how to settle the question. Joseph Henry was chosen. His idea was accepted and acted upon. "To *increase knowledge* men were to be stimulated to original research by the offer of rewards for original memoirs on all subjects of investigation; to *diffuse knowledge* the results of such research were to be published;" and in addition it was decided to issue a series of reports giving an account of new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional; as well as to publish occasionally separate treatises of general interest; and all these were to be distributed amongst the public institutions of the world.

In the result the Smithsonian Institution was established for the promotion of original research, and the diffusion of the same, and it now distributes to 3700 public institutions in Europe, Asia, Africa, and America, the following publications:—

"The Smithsonian Contributions to Knowledge," of which twenty-six volumes in a quarto series have been issued, comprising memoirs and records of original investigations; researches in what are believed to be new truths; efforts to increase human knowledge. "The Smithsonian Miscellaneous Collections," an octavo series, already numbering thirty-four volumes, containing reports on the present state of our knowledge of particular branches of science; instructions for digesting and collecting facts and materials for research; lists and synopses of species of the organic and inorganic world; reports of explorations; aids to bibliographical investigations, &c. "The Annual Reports of the Board of Regents of the

[1] *Harvard Annals*, vol. xviii. p. 138.
[2] Recommended in the *Century Magazine* for September 1888, as well as in "Washburn Publications," vol. ii. p. 113.

Smithsonian Institution" (thirty-two volumes), containing also very valuable records, catalogues, and memoirs.

Another part of the income was applied in accordance with the requirements of the Act of Congress to the gradual formation of a library and a museum. But in 1866 the library was amalgamated with the Library of Congress and lodged in the Capitol. The Library, however is, open throughout the year with equal facilities for students, including the free use of the books of both collections. In 1852, Mr. Henry established what is known as the "Smithsonian system of exchanges," whereby, in exchange for those of America, the scientific publications of Societies and individuals throughout the civilized world are made accessible without cost to the students of science in America. This system has added to the Library almost complete series of the Transactions of many of the older Societies of England, France, and Germany, which it would now be difficult if not impossible to replace. They comprise hundreds of works which, like those of the Societies in question, can be obtained in no other way than by exchange. The collection is now the best in existence.

In his evidence before the Royal Commission on Scientific Instruction (English), June 1870, Mr. Henry said:—

"This is considered a very important part of the plan of operations. Not only are books distributed, but the Institution has commenced the practice of distributing specimens of natural history over the world and getting others in exchange. As an interesting fact in connection with this system, I may mention that all the lines of steamers convey the Smithsonian packages free of cost, and also that they are admitted through all Custom houses without being opened, and free from all duties in all countries."

This generous system is still in operation, and has been very much extended.

In 1858 the United States Government transferred the National Museum (established 1842) to the custody of the Smithsonian Institution with the same amount of annual appropriation ($4000) which had been granted to the United States Patent Office when in charge of it; but this annual appropriation has now been increased to about $40,000. A new Museum was built at a cost of $350,000.00, and at the last session of Congress a Bill appropriating $500,000.00 for the construction of a second Museum building passed the Senate, but was not brought to vote in the House of Representatives. The Secretary has no doubt, however, but that in a year or two a building much larger than the present one will be supplied.

The National Museum is in three divisions—the Museum of Record, the Museum of Research, and the Educational Museum—and there are departments, with twenty-four curators and sub-curators, of arts and industries, ethnology, antiquities, mammals, birds, fishes, comparative anatomy, mollusks, insects, marine invertebrates, invertebrate fossils, plants, minerals, lithology and physical geology, metallurgy and economic geology. There are, in addition, chemical and natural history laboratories, and a bureau of ethnology.

"So rapidly were the treasures of the Museum increased by the gathered fruits of various Government explorations and surveys, as well as by the voluntary contributions of the numerous and widespread tributaries of the Institution, that the policy was early adopted of freely distributing duplicate specimens to other institutions where they would be most appreciated and most usefully applied. And in this way the Smithsonian became a valuable centre of diffusion of the means of investigation. The clear foresight which announced that the Museum must soon outgrow the entire capacity of the Smithsonian resources was amply vindicated; but the strong desire of Joseph Henry to see established in Washington a *National* Museum he did not live to see gratified" ("Memorial of Joseph Henry," discourse of W. B. Taylor, p. 285). He died May 13, 1878.

An extensive system of meteorological observations was instituted in 1849. About six hundred observers, scattered over the United States and the Territories, became voluntary correspondents of the Institution. This department was transferred in 1872 to the newly-established Meteorological Department established by the Government under the Signal Office of the War Department. The digested observations have been published in the "Contributions to Knowledge."

The memoirs in the quarto volumes of the "Contributions to Knowledge" (over 120) are universally recognized as valuable original authorities on their respective topics. There is no restriction as to the subject of research, and they consist of archæological, anthropological, botanical, geological, palæontological, meteorological, magnetical, physical, physiological, and philological observations, investigations on the solar system, the laws of atmospheric circulation, and systems of consanguinity and affinity. They have undoubtedly tended "to increase and diffuse knowledge."

The thirty-odd volumes of the "Smithsonian Miscellaneous Collections" are of a more technical character than the "Contributions," including systematic and statistical compilations, scientific summaries, and valuable accessions of tabular "constants." Scientific men generally have applauded the value and acknowledged their indebtedness to publications comprised in this series, which include such scientific classics as Clark's "Constants of Nature," Guyot's "Meteorological and Physical Tables," Watson's "North American Botany," Binney and Tryon's "Land and Fresh-water Shells of North America"; North American "Coleoptera" by Le Conte, "Diptera" by Loew, "Lepidoptera" by Morris, and "Neuroptera" by Hagen.

All these are distributed over every portion of the civilized and colonized world, and constitute a monument to the memory of James Smithson, such as never before was built on the foundation of one hundred thousand pounds.

II.—The Johns Hopkins University, Baltimore.

Johns Hopkins, a merchant of Baltimore, who died in 1873, in the seventy-ninth year of his age, bequeathed a large part of his fortune to two institutions which perpetuate his name—the Johns Hopkins University and the Johns Hopkins Hospital. Each foundation received an endowment of not far from three and a half million dollars, or about £700,000. The two institutions are separate corporations, but are closely affiliated. The University has just concluded its thirteenth year of work. Since its opening, in 1876, it has issued frequent statements of the development of its plans in the form of Annual Reports.

The Johns Hopkins University is an unsectarian foundation. There is no test for the assent of students or Professors. This is the especial privilege of the new institutions for higher education that have sprung up of late years. "No hungry tradition treads them down." They approach the problem of education untrammelled by customary practice; yet, utilizing the experience gained by the older Universities, they make more independent and original attempts at its solution.

Universities as a rule have grown from an aggregation of Colleges; the University, in process of time, being evolved as a supplement to collegiate training. The Johns Hopkins University is an exception to this rule. In accordance with the terms of the gifts, the institution started with the idea of the University, in the higher conception of that word, as a universal school and a fostering mother. Not merely a place in which degrees are granted in the Faculties of Arts, Sciences, Divinity, Law, or Medicine, but as an organized force for the education of the community of the district in which it is placed, for deepening, purifying, and strengthening all good influences on the men, and the alliance of the men with the institutions. Institutions remain, but the men pass away—

"The individual withers, and the world is more and more."

According to the thirteenth Annual Report of the University (September 1887 to September 1888), it appears that the academic staff included 57 Professors, Associate Professors, and Lecturers. There were 420 students; 199 were residents of Maryland, 196 came from other States of the Union, and 25 from foreign countries; 231 had already graduated, 127 had matriculated for the degree of B.A., and 62 were admitted as special students to pursue courses of study for which they seemed fitted, without reference to graduation. The University does not provide lodging or board.

There are seven distinct and parallel courses of College instruction adapted for matriculation, and the various elective groups for the degree examinations in the University. The subjects of the Professors and Lecturers last session were: history, political economy, mathematics, astronomy, physics, chemistry, mineralogy, geology, biology, psychology, pedagogics, pathology, Greek, Latin, Sanskrit, Indo-European philology, Shemitic languages, Romance languages, Teutonic languages, Anglo-Saxon, and English. The large and well-appointed physical, chemical, and biological laboratories of the University have already been detailed in NATURE (vol. xxxiii. p. 237).

Two degrees only are granted—the Bachelor of Arts and the Doctor of Philosophy; and since degrees were first conferred in 1878, 177 have attained the Baccalaureate degree, and 131 have been advanced to the degree of Doctor of Philosophy.

There are twenty Fellowships of $500 each. The examination for these is, in a certain sense, competitive, but not with uniform tests, nor by formal questions submitted to the candidates. The applicants' previous record, and the Professors' record, is taken into consideration.

"Those who are appointed are expected to proceed to the degree of Doctor of Philosophy. The appointments are not made as rewards for good work already done, but as aids and incentives to good work in the future; in other words, the Fellowships are not so much honour and prizes bestowed for past achievements, as helps to further progress and stepping-stones to honourable intellectual careers. They are not offered to those who are definitely looking forward to the practice of any one of the three learned professions (though such persons are not formally excluded from the competition), but are bestowed almost exclusively on young men desirous of becoming teachers of science or literature, or proposing to devote their lives to special branches of learning which lie outside of the ordinary studies of the lawyer, the physician, or the minister. Appointments are rarely, if ever, made of graduates of more than five years' standing."

There are also twenty graduate scholarships of $200 each for those who have taken the baccalaureate degree. There are also thirty-eight ordinary and honorary Hopkins Scholarships ($250 annually and free tuition) for promising young men.

Courses of public lectures, designed primarily for the members of the University, and supplementary to the regular class-room work, are given each session. The admission of the public is by ticket, to be previously obtained free. The courses for 1887-88 included: ten lectures on some of the problems of great cities; six lectures on the local study of natural history; nine lectures on the history of the science of electricity and magnetism; eleven lectures on the causes which led to the French Revolution; four lectures on Greek lyric poetry; eight lectures on the topography of Athens.

The University Library consists of 35,000 volumes. And it is lately reported that the valuable scientific collection of the Maryland Academy of Sciences has been presented to the University.

But the great point of this institution is its efforts in the direction of the endowment of scientific research. Prof. Newcomb, one of the Professors of the University, said in 1876 of America what is very true of Great Britain: "We are deficient in the number of men actively devoted to scientific research of the higher types; in public recognition of the labours of those who are so engaged; in the machinery for making the public acquainted with their labours and their wants; and in the preliminary means for publishing their researches." The Johns Hopkins University has encouraged scientific research, and the publication of its results, to a large extent; not only by training young men in the methods of exact science, and fitting them for the scientific service of the Government, for scientific and technical laboratories, and for the teaching profession, but also by the publication of journals and monographs detailing the results of scientific study. The trustees, determining to encourage the heads of departments and other qualified scholars to contribute each in his own way to the advancement of the science which he professed, started five periodicals, conducted by Professors and graduates, and aided by the University chest, namely: *The American Journal of Mathematics*, 10 vols., edited by Prof. Newcomb; *The American Chemical Journal*, 10 vols., edited by Prof. Remsen; *The American Journal of Philology*, 9 vols., edited by Prof. Gildersleeve; *Studies from the Biological Laboratory*, 4 vols., edited by Prof. Martin and Dr. Brooks; and the *Johns Hopkins University Studies in Historical and Political Science*, edited by Prof. H. B. Adams, the seventh series of which is in progress. All of these publications are considered on both sides of the Atlantic to be of the greatest value. *The American Journal of Psychology*, *Modern Language Notes*, and *Contributions to the Study of Archæology*, are also edited by members of the academic staff, and there are University Societies on all these subjects.

The University also publishes *University Circulars* monthly, containing scientific notes in biology, chemistry, history, political science, mathematics, physics, philology, philosophy, logic, &c., besides the usual Annual Reports and special publications, such as the "Reports of the Chesapeake Zoological Laboratory." This is a laboratory of about fifty individuals at ten stations, and the results of their work at the sea-shore, in the study of natural laws in their simplest manifestations, from 1879 to 1886 include ninety-nine titles.

Dr. Gilman, the President of the University, reported at the tenth anniversary that 176 former students were known to be engaged in the work of teaching, mostly in colleges; and that among the former pupils are eighty physicians, thirty-eight ministers, and thirty-four lawyers. There were no exact statistics of those engaged in scientific pursuits.

Such are the beginnings of the Johns Hopkins University. Those engaged in the work of higher education in this country will appreciate fully the fortunate circumstances in the inception of the institution: a benefaction of £700,000 for endowment; carefully selected trustees, to whose wisdom, moderation, and far-sightedness much is due; a wisely organized constitution; able Professors and teachers, gauged by the standard of work done and success achieved; and foundations to assist all these contributed by a critical and discerning public. The institution started full of promise, and it is redeeming its promise with a rapidity unparalleled in the history of academic institutions.

J. TAYLOR KAY.

THE MEETING OF THE BRITISH ASSOCIATION AT NEWCASTLE-ON-TYNE.

THE arrangements of the Local Committee are nearly completed for the reception of the British Association on the occasion of its fifty-ninth annual meeting, which, as our readers are aware, is to be held in Newcastle-on-Tyne, and will commence on September 11. This will be the third occasion on which the Association has held its annual Congress in Newcastle-on-Tyne, the last being in 1863—a meeting memorable as being the largest gathering of members and friends of the Association, which has only been once exceeded in point of numbers, viz. by the Manchester meeting of 1887. No efforts have been spared on the part of the Committee to make preparations for a meeting which, it is hoped, will prove as successful and interesting to the members as the former meeting proved; and in their endeavours to do this, the work of the Committee has been greatly facilitated by the many notable additions, in the shape of buildings suitable for the purposes of the Association, which have been erected since 1863.

The reception-rooms, occupying a central position with respect to the various Section rooms, will be located in the new buildings of the University of Durham College of Medicine, Bath Road, in which building a writing-room and ladies' drawing-room will be provided, also special rooms for the use of the officers of the Association. The Cambridge Drill Hall, near the reception-room, is to be fitted up for a luncheon-room. Sections A and B will meet in the new buildings of the College of Science, opened in November last by H.R.H. Princess Louise; and in the chemical laboratory of this College it is intended to bring together a series of exhibits illustrating the chemical and allied manufactures of the district. The general meetings of the Association will be held in the St. George's Drill Hall.

The Natural History Museum, opened by H.R.H. the Prince of Wales in 1884, in which building is Mr. Hancock's unique collection of British birds, will be used for the two *soirées;* the first is to be given by the Mayor and Corporation, and the second by the Local Committee.

A guide-book, arranged in three sections, has been prepared for the occasion of the Association's visit, dealing respectively with the history and topography, the geology and natural history, and the industries of the district. The first section is edited by the Rev. J. Collingwood Bruce; the second by Prof. Lebour; and the third by Mr. Wigham Richardson.

The Durham, Northumberland, and Newcastle-on-Tyne Botanical and Horticultural Society has arranged to hold its autumn show during the time of the meeting, and on Wednesday, September 11—the first day of the show—it will be open to members free on presentation of their tickets.

On the Saturday, half-day excursions have been arranged to the following places of interest: Morpeth, Wallington, Seaton Delaval, Hexham, Marsden, Prudhoe, Durham, and an excursion down the river. The Senate of the University of Durham proposes to hold a special Convocation on the Saturday for the purpose of conferring honorary degrees on the President and other officers of the Association. Convocation will be followed by a luncheon, to which 200 members of the Association will be invited, after which there will be a special service in the Cathedral.

Thursday, the last day of the meeting, is to be devoted to whole-day excursions to the following places: Alnwick, Cragside (the seat of Lord Armstrong), Middlesbrough, Berwick, Lanercost, Beal, Little Mile, Belford, Raby, Bardon Mill, and Middleton-in-Teesdale.

The principal works in Newcastle and on the Tyne will be thrown open to members for inspection during the meeting.

The railway company is prepared, during the meeting, to issue tickets at reduced rates to and from places in the neighbourhood, and to run special trains, so that members, should they wish to do so, will be able to reside in the country or on the coast, and get to and fro conveniently. Through the kindness of the authorities of University College and of Hatfield Hall, Durham, the Local Committee are enabled to place the students' rooms in these buildings on their hotel and lodgings list, which list will also be found to contain the addresses of several places in Tynemouth, Cullercoats, and Whitley, on the coast.

THE NEW BUILDINGS OF THE SORBONNE.

IN England we are still fighting about the question whether London is or is not to have a teaching University. It is significant that Frenchmen have no soit of doubt as to the necessity of such an institution in Paris. During the long and splendid history of the Sorbonne they have had ample experience of the value of a great teaching body in the capital; and the result is that this is one of the institutions in which men of all parties take a common pride.

So long ago as 1855 it was decided that new buildings for the Sorbonne should be erected, but the scheme was not really complete until 1881. It was then estimated that the expense would be 22,000,000 francs—a formidable enough sum, but one which caused no serious difficulty, as the city readily undertook to contribute half of it. The foundation was laid in 1885, and now a considerable part of the work is finished. This was opened on Monday, in the presence of the Head of the State, and the ceremonies on the occasion may be regarded as affording fresh evidence of the enthusiasm felt by educated Frenchmen for all that represents and tends to develop the highest intellectual life of the nation. Every University had been asked to send delegates elected by the students to the celebration; and the State, and the City of Paris, agreed to look upon them as their guests during the ten days of festivity in honour of science. "This part of the programme," says the Paris Correspondent of the *Daily News*, "has been well carried out, arrangements having been made with different hotels to board and lodge the foreign visitors at the expense of the Hôtel de Ville and the Ministry of Public Instruction. Russia and Germany have not accepted invitations, but the Universities of Great Britain, of the Scandinavian countries, of Belgium, Holland, Greece, Switzerland, Italy, Spain, and the United States are represented. There are about 700 delegates from these countries, besides a large number who have come at their own expense."

The *fêtes* began on Sunday evening with a gala performance of "Faust" at the Opera House, which the President attended. On Monday, 3000 persons assembled in the new amphitheatre, an immense hall adorned with frescoes. Each delegation had a standard-bearer carrying the flag of his nation, and the members of the various groups were warmly greeted by the public as they advanced to the places appointed for them. At 3 o'clock M. Carnot arrived, and took his seat on the platform, surrounded by Ambassadors, statesmen, and Academicians. M. Ferry, as the Minister who made the arrangements for the enlargement, was much cheered.

M. Gréard, Rector of the Academy, made the first speech. He sketched the history of the Paris University, extolled the events of 1789, and described study as a common Fatherland, which had brought together delegates from nearly all the European and American Universities. M. Hermite next reviewed the mathematical teaching of the Sorbonne since 1808. M. Chautemps, President of the Municipality, vindicated democracy from the imputation of indifference to culture, and claimed credit for the body represented by him for having founded a Chair of French Revolution History and a Chair of Evolution. M. Fallières, Minister of Education, dwelt on the efforts and sacrifices of the Republic for the diffusion of culture. He referred to the moribund condition of the Universities on the eve of the Revolution, and the want of cohesion between the colleges afterwards established, and eulogized the individuality now developed by the provincial Universities.

NOTES.

AT the annual graduation ceremony at the close of the summer session of the University of Edinburgh, last week, Prof. T. R. Fraser intimated that the important Cameron Prize in Therapeutics, the recipient of which might be selected from any country, had been awarded to M. Pasteur, a Doctor of Laws of Edinburgh University, in recognition of the high importance and great value in practical therapeutics of the treatment of hydrophobia discovered by him.

THE fifty-seventh annual meeting of the British Medical Assotion will begin at Leeds on Tuesday, the 13th inst., and go on until the 16th, under the presidency of Mr. C. G. Wheelhouse. The President's address will be delivered on the evening of the 13th. On the 14th, an address in medicine will be given by Dr. Hughlings Jackson, F.R.S., and afterwards the Stewart Prize will be presented to Dr. Klein, F.R.S., for his work in bacteriology and scarlet fever. On the 15th, an address in surgery will be given by Dr. Pridgin Teal, F.R.S., and on the 16th, Sir James Crichton Browne, F.R.S., will deliver an address in psychology.

AT the Academy of Medicine, Paris, in the grand amphitheatre, a numerous and distinguished audience gathered on Sunday for the first sitting of the International Congress of Hygiene. The chair was taken by Prof. Brouardel, with Dr. Chautemps, President of the Paris Municipal Council, and Sir Douglas Galton as Vice-Presidents. Sir Douglas Galton returned thanks on behalf of the various English Sanitary Societies, represented at the Congress by ten English delegates. He promised a hearty welcome to the French hygienists, who, he hoped, would in great numbers attend the next International Congress, to be held, as arranged, in London in 1891. The work of the Congress began in earnest on Monday, and among the subjects discussed was a proposition submitted by Dr. Jablowski, the Russian delegate, to the effect that children suffering from tuberculosis of the lungs, or even only suspected to have this complaint, should be sent back from school to their families. This proposal was rejected, but it was considered that the school doctor should exclude such pupils as by the dangerous character of their expectorations might spread the specific germ of pulmonary consumption. On Tuesday there was a discussion on the inspection of unwholesome dwellings; and in connection with "the dust-bin grievance" the Congress unanimously passed a resolution that kitchen refuse should never be kept in the house over night, that it should be placed outside in metallic boxes, and that it should be removed every twenty-four hours.

IN his interesting speech on the Education Estimates on Monday, Sir W. Hart Dyke had much to say about the new Code, the enforcing of which he has been obliged to postpone. He showed that it would "open and widen the curriculum," and referred especially to the advantages it would confer on small schools in the midst of a scattered agricultural population. The mass of our agricultural schools in England and Wales did nothing but just pass their scholars through the elementary subjects. Both sides of the House regarded that as a most deplorable thing. Questions had been put to him from time to time as to teaching agriculture in the rural schools. Knowing something of rural school life, he should do nothing so absurd as to attempt to turn out first-rate agriculturists from our elementary schools. But there was a vast difference between that and turning children out knowing nothing of plants or botany or of insect life, and what was useful and what was injurious to agriculture. A vast deal of good might be done by training in regard to these matters. What they proposed to do was to provide that any scholar might attend elementary science classes at district centres. At present, in towns as well as in agricultural districts, more combination was required between schools to enable them to carry out different kinds of teaching. What one school was unable to do, a group of three or four, with little trouble and with an economy of expenditure, might readily carry out. Sir John Lubbock and Sir Henry Roscoe expressed much regret that the new Code had been for the present withdrawn, and hoped that it would be introduced again next session.

THE committee of the national association for the promotion of technical education have issued their second annual report. They think they may fairly congratulate the members on the progress made by the movement during the past year. On May 1, 1888, an anonymous donor offered to contribute £500 to the funds of the association, provided £1000 were raised from other sources before May 1, 1889. The support received from the public has been such that the committee have secured this donation. They refer with especial satisfaction to the support received from representative bodies of working men. No fewer than thirty-one working men's Co-operative Societies have given donations or subscriptions during the year, and many more are in complete accord with the aims of the association. The committee hope that with the resources now at their disposal they may be able to extend their work, particularly in the department of secondary education, but they appeal for a larger number of annual subscriptions. Nothing has occurred to weaken their belief in the magnitude and urgency of the work which needs to be carried out to improve, develop, and harmonize, and bring into close relations one with another, the elementary, secondary, and technical education of the country.

THE establishment of a technical school at Frankfort-on-Maine for young artisans and mechanics was planned long since by different corporations in that city, and from a statement made lately by the mayor, it appears that all the expenses in connection with the school are to be borne by the city, which will also give the rooms and see to the appointment of the teachers. The lessons will be given on Sundays and in the evening on week days. The pupils will be charged a very moderate tuition fee only. Great energy is displayed in order to open this school very shortly, says the British Consul in his last Report, as the accomplishment of the scheme will be hailed with great satisfaction throughout the city.

THE death of Mr. C. Spence Bate, F.R.S., at Plymouth, is announced. He was the author of the "Report of the Crustacea Macrura dredged by H.M.S. *Challenger*, during the years 1873–76." He was also the author of the "Catalogue of the Specimens of Amphipodous Crustacea in the Collection of the British Museum"; and of a work on "The Pathology of Dental Caries." In conjunction with Mr. J. O. Westwood, Mr. Bate wrote "A History of the British Sessile-eyed Crustacea."

DURING last week Mr. John Aitken visited the Ben Nevis Observatory in connection with the proposed investigation into the number of dust particles in the atmosphere. From observations made by him and Mr. Omond, the numbers varied from 350 per cubic centimetre about noon to 500 at 3 p.m. The purest air previously examined by Mr. Aitken was on the Ayrshire coast, and gave 1260 dust particles to the cubic centimetre. It is, of course, premature to draw conclusions from these observations, but it may be suggested that extended observation will in all probability establish the fact of the singular purity of the air at this height, as compared with that at lower levels; and that the numbers of dust particles will be greatest at the Observatory in that part of the day when the ascending currents up the heated sides of the mountain are strongest.

REFERENCE was made in our last issue (p. 326) to the drought on the top of Ben Nevis in June last. In that month the hours of sunshine registered by the sunshine recorder were 250, a number considerably in excess of any previous month, the highest having been 206 hours in June 1887. With the early disappearance of the snow and strong sunshine of June, such vegetation as is found at these heights is well forward. On July 22, fine specimens of *Silene maritima*, about 8 inches in height, well grown, with abundant flowers, many of them in seed well matured, were gathered on Cairn Dearg, one of the lower heights of the mountain, at a height of 3800 feet above the sea. In Hooker's "Flora of the British Islands," the limiting height of this plant is given at 3000 feet.

THE Report of the Director of the Hong Kong Observatory, for 1888, has been issued. It is an interesting and exhaustive document. In reference to thunderstorms in the colony during the past five years, Dr. Doberck states that they are most frequent in May, and that they have not occurred in November, December, and January. They seldom happen in February. With reference to the daily variation, they are more frequent at night than during the day-time in the proportion of three to two. They appear to be most abundant about 1 a m., and least so about 8 a.m., in the proportion of about two to one. During the past year the temperature was on an average higher than in previous years, and rose higher than before on hot days. This appears to have been at least partly due to a more southerly direction of the wind, but the temperature has been rising on the whole since 1884. Whether this is periodical remains to be investigated. The Director thinks there are fair prospects of finding it is so. The past year was more damp than usual, the rainfall was heavy, and the mean barometer below the average. The amount of sunshine was less, and the cloudiness greater than usual. It is generally considered to have been an unhealthy year.

Science says that in 1887–88 the courses in astronomy at the Johns Hopkins University were so extended as to justify its being chosen as a principal subject by candidates for the degree of Doctor of Philosophy. A small observatory has been erected, and is fitted up with a meridian circle by Fauth and Co., a portable transit instrument by Troughton, a clock, a chronograph, and other subsidiary apparatus. In the dome of the physical laboratory is mounted an equatorial of 9½ inches aperture, so fitted that the student can learn to make the usual determinations with the largest instruments of that class. The work in astronomy consists of a study of the history and practice of the subject, supplemented by instruction in the use of the instruments, and exercises in astronomical computation. During the year 1889–90 the courses are intended to cover a wider range of individual subjects than usual.

THE Royal Society of New South Wales offers its medal and a money prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects. To be sent in not later than May 1, 1890:—The influence of the Australian climate (general and local) in the development and modification of disease—the Society's Medal and £25; on the silver ore deposits of New South Wales—the Society's Medal and £25; on the occurrence of precious stones in New South Wales, with a description of the deposits in which they are found—the Society's Medal and £25. To be sent in not later than May 1, 1891:—The meteorology of Australia, New Zealand, and Tasmania—the Society's Medal and £25; anatomy and life-history of the Echidna and Platypus—the Society's Medal and £25; the microscopic structure of Australian rocks—the Society's Medal and £25. The competition is in no way confined to members of the Society, nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor.

AT a recent meeting of the Genevan Society of Physics and Natural History, M. Mallet exhibited two balls of almost perfect sphericity, about 4 inches in diameter, one black, and of vegetable origin, the other white, and of mineral origin, but both produced by a mechanical movement. The black ball had been found with another in a piece of oak which had long served as the shaft of a mill-wheel. A cavity having formed in the wood, through disease or the work of some insect, the dust of the wood, with acquired moisture, had been rolled into this spherical form, growing in size, like a snowball (a slow process of many years probably, as the wheel was very old). The white ball, a calcareous pebble, was found with many others in a grotto traversed by a torrent which flowed into the Rhone.

FOUR years ago a light-ship was stationed in the Baltic, between the Islands of Bornholm and Rügen, and the currents there have been measured on 294 days in a year, every two hours, with interesting results (described by Herr Dinklage in the *Annalen der Hydrographie*). It is found that the currents vary most irregularly in direction, strength, and duration, but in most cases follow the prevailing winds (of which the westerly are the most frequent). Currents which did not diverge more than 90° from the wind's direction being counted as similar in direction, 86 per cent. were of this nature. The relation becomes more pronounced when only winds and currents above a certain limit of force are considered. A sudden change in direction of wind is soon followed by a change in that of current. The effect of wind direction on current direction is certainly apparent the first day, and to a depth of at least 5 metres. The direction of current rarely coincides exactly with that of wind, and divergence to the right is distinctly more frequent than divergence to the left. As this cannot be attributed to the form of neighbouring coasts or to the circulation of winds (for winds in our latitudes turn mostly the other way), the author regards the effect as due to the rotation of the earth.

THE Northern Lighthouse Board have adopted Priestman's oil engines for blowing fog signals in preference to steam or gas engines. A great saving is thus effected in first cost, no chimney being required as in the case of a steam engine, nor gas works, which would be needful if a gas engine were adopted.

THE first part of the Journal of the College of Science of the Imperial University of Japan, which has just been published, contains two papers illustrated by numerous excellent plates. The first is by Prof. Matsujiro Yokoyama, on the subject of "Jurassic Plants from Kaga, Hida, and Echizen," three provinces on the west coast of Japan. It is a valuable contribution to our knowledge of the fossil flora of Japan, a subject hitherto little investigated. Prof. Yokoyama's specimens were collected, for the most part, by the Geological Survey of Japan.

His descriptions and classification show a thorough acquaintance with the subject. The conclusion he arrives at is that the "Jurassic flora of Kaga, Hida, and Echizen belongs to the same geological horizon as the flora of Siberia, Spitzbergen, and Yorkshire—namely, to the Bathonian stage of the Inferior Oolite with special relations to the flora of Siberia." The second paper is by Prof. Yasushi Kikuchi, on "Pyroxenic Components in certain Volcanic Rocks from the Bonin Islands."

IN his Annual Report on Education in Hong Kong, Dr. Eitel, the Government Inspector of Schools, says that the total number of educational institutions of all descriptions known to have been at work in the colony of Hong Kong during the year 1888 amounts to 206 schools, with a grand total of 8717 scholars. More than three-fourths of the whole number of scholars—that is to say, 6728—attended schools (99 in number) which are subject to Government supervision, and either established or aided by Government in some form or other. The remainder—viz. 107 schools, with 1989 scholars—are private institutions entirely independent of Government supervision, and receiving no aid from public funds, except that they are exempt from payment of rates and taxes.

M. TAUPIN, who was recently despatched by the Governor-General of French Indo-China to the Laos States on an exploration, has presented a report of the results, which he sums up as follows:—"I have studied the language and system of writing of the Laos—that is, of the only population in the world possessing a graphic-alphabetical system. Of this there has been up to the present no positive knowledge. It was only known that the Laotian language and writing were somewhat similar to those of Siam. The language is spoken by about four millions of people. I have collected interesting information relating to the natural history of these regions, and much commercial information. . . . I have made numerous meteorological observations, and taken a large number of anthropometrical measurements according to the Broca system."

IN the *Izvestia* of the Moscow Society of the Friends of Natural Science, vol. lxiii., there is an exhaustive work, by M. Kharuzin, on the Kirghizes. The anthropological data relative to the great Bukéeff stem are fully presented, and illustrated by sixteen photographs. The writer also describes the religious beliefs of the Kirghizes, their religious festivities and worship, and their customary law. An appendix contains the results of the excavation of thirty-six *koorgans* in the Kirghiz Steppe.

THE Governor of Jamaica, in his Report regarding the progress of the colony during the past year, says that the Department of Public Gardens and Plantations has done much useful work, and that the distribution and collection of valuable economic plants have been actively carried on. The Hope Gardens, which are intended to take the place of those at Castleton, as the head botanical station, have made good progress, but as they are young, and the authorized annual expenditure limited, some time must elapse before they will be complete. Although they are 19 miles from Kingston, they attract a large number of visitors. At the cinchona plantation actual cultivation has ceased so far as planting operations are concerned, but the establishment of a hill garden there has been attended to. No cinchona bark was shipped during the year, but bark has been supplied to the Government analytical chemist for preparation of a liquid extract of a febrifuge manufactured according to a method adopted by Mr. Hooper, Government Quinologist in the Nilgiris, and which is to be tested by the Medical Department of the colony. Attention is directed to the propagation at Castleton of the Manilla hemp plant with a view to its introduction into different parts of the island, and it is pointed out that even if the fibre is not utilized as an article of export, it may supply a local demand for rope, and so save such a valuable timber-tree as the "mahoe," of which large numbers are annually destroyed by the peasantry by being stripped of their bark, which is twisted into ropes. Another interesting circumstance alluded to is the successful experiment of grafting the mangostien (which, although growing at Castleton for many years, has only recently reached the fruiting stage) upon the gamboge tree of common growth.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♀) from India, presented by Mr. H. J. Cunnington; a Peregrine Falcon (*Falco peregrinus*), captured at sea, presented by Captain Watson; an Indian Fruit Bat (*Pteropus medius* ♂) from India, presented by Mr. Tholen; an Ocelot (*Felis pardalis*) and a Brazilian Cariama (*Cariama cristata*) from South America, presented by Captain W. Heathorn Lacy; a Tuberculated Iguana (*Iguana tuberculata*) from Brazil, presented by Mr. H. E. Blandford; three Palm Squirrels (*Sciurus palmarum*) from India, purchased; an Indian Python (*Python molorus*) from India, deposited; and ten Gold Pheasants (*Thaumalea picta*), bred in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *AUGUST* 11–17.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 11

Sun rises, 4h. 41m.; souths, 12h. 4m. 56·3s.; daily decrease of southing, 9·7s.; sets, 19h. 28m.: right asc. on meridian, 9h. 25·5m.; decl. 15° 9′ N. Sidereal Time at Sunset, 16h. 50m.

Moon (Full on August 11, 5h.) rises, 19h. 36m.*; souths, 23h. 58m.*; sets, 4h. 28m.: right asc. on meridian, 21h. 16·5m.; decl. 18° 54′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° ′
Mercury..	4 56	12 22	19 48	9 43·2	15 34 N.
Venus ...	1 3	9 5	17 7	6 25·0	21 17 N.
Mars ...	3 4	11 1	18 58	8 21·3	20 34 N.
Jupiter ...	16 39	20 32	0 25*	17 54·4	23 24 S.
Saturn ...	5 1	12 23	19 45	9 43·7	14 53 N.
Uranus ...	10 20	15 49	21 18	13 10·3	6 50 S.
Neptune..	23 1*	6 51	14 41	4 10·9	19 25 N.

* Indicates that the rising and southing are those of the preceding evening and the setting that of the following morning.

Aug.	h.	
11	14	Mercury in conjunction with and 0° 38′ north of Saturn.
16	14	Saturn in conjunction with the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
o Ceti (Mira)	2 13·7	3 28 S.	Aug. 11,		*M*
δ Libræ	14 55·1	8 5 S.	,, 15,	1 40	*m*
V Coronæ	15 45·6	39 54 N.	,, 11,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 13,	1 36	*m*
		and at intervals of		20 8	
X Sagittarii	17 40·6	27 47 S.	Aug. 12,	0 0	*M*
			,, 16,	3 0	*m*
W Sagittarii	17 57·9	29 35 S.	,, 11,	3 0	*M*
U Aquilæ	19 23·4	7 16 S.	,, 15,	0 0	*m*
η Aquilæ	19 46·8	0 43 N.	,, 15,	3 0	*M*
R Sagittæ	20 9·0	16 23 N.	,, 16,		*m*
W Cygni	21 31·9	44 53 N.	,, 11,		*m*
δ Cephei	22 25·1	57 51 N.	,, 15,	2 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
The *Perseids*	44°	56 N.	Swift; streaks.
Near *μ* Persei	60	48 N.	,, ,,
,, *η* Aurigæ	74	41 N.	,, ,,
,, δ Draconis	290	70 N.	Swift.

Ephemeris of Comet Davidson (*by Krueger*).

Greenwich Civil Time. h.		Right Ascension. h. m. s.		Declination. ° ′
August 10...0	...	15 7 26	...	8 15 N.
12...0	...	15 16 18	...	10 55
14...0	...	15 24 21	...	13 14
16...0	...	15 31 43	...	15 17 N.

Comet diminishing in brightness.

GEOGRAPHICAL NOTES.

We regret to learn of the death of Lieutenant Tappenbeck in the Cameroons. He, with Lieutenant Kund, had been doing good work in the Cameroons interior, as they had before done in the Congo region. Lieutenant Kund has returned to Berlin, and has been describing the results of his second journey into the interior. In general, he and his companions followed the same route as on the previous expedition, and were received in quite a friendly way by the natives who had before attacked them. Very interesting observations were made as to the ethnological conditions of the South Cameroons region. A spot was selected for a station, of which the late Lieutenant Tappenbeck was to have been chief. The region is close to the limit of distribution of the Bantus, and there is a considerable variety of ethnological mixtures. Within the limits of the primæval forest, which lies behind the narrow coast stretch, the explorers came upon an almost dwarfish tribe, with yellow skins, hunting in scattered hordes, and building only temporary shelters for themselves. On the plateau, again, the explorers met with a free and friendly population of large, strong, and handsome men, with a well-organized social system. Quite different from the degraded coast people and the decaying forest people, these highland tribes have preserved the original good features of their race; and among them, Lieutenant Kund thinks, the scientific and industrial development of the Cameroons might be carried out.

Everyone interested in geographical exploration will be sorry to hear of the death, apparently by assassination, of M. Camille Douls, while on his way across the Sahara towards Timbuctoo. M. Douls was born at Bordes, in Aveyron, in 1864. In 1881 he visited the Antilles and Central America; and four years afterwards he spent some time in Morocco, studying the language and manners of the Arabs. In 1887 he explored the unvisited western regions of the Sahara; and last year he started on the journey which was destined, unhappily, to be his last.

Mr. Ernest Favenc describes in the August number of the Proceedings of the Royal Geographical Society, the results of a recent exploring journey in West Australia, in the country situated about 24° S. lat. The result of the trip was the discovery of several large tributary rivers of the Ashburton, running through magnificent pastoral country. Mr. Favenc found the physical features of the country different entirely to the conjectural ones placed on some of the maps of West Australia. Still there is a very great scarcity of water, many of the river beds being quite empty. The geological formation of the Ashburton is against the likelihood of any valuable mineral deposits being discovered in the future. There seem, however, to be indications of a gold reef at the head of the Gascoyne.

Colonel Antonio R. P. Labre, a Brazilian gentleman, has for some time been doing important exploring work in the region between the Beni and Madre de Dios rivers and the Purus. These great South American rivers have been often enough followed along their courses, but no one had attempted to penetrate through the primæval forests that separate their courses. This is what Colonel Labre has done, his leading object being to explore the india-rubber resources of the region. There are many rubber stations along these rivers, mainly occupied by Bolivians. The principal journey of Colonel Labre was undertaken for the purpose of crossing westward from the india-rubber settlements on the Madre de Dios to the nearest navigable point on the Aquiry tributary of the Purus, and ascertaining if the distance and the nature of the ground presented facilities for the construction of a road, and ultimately of a railway. He ascended the Madeira from the Amazons, and although this is the only route by which the considerable trade to and fro between the Amazons and Bolivia is carried on, it took Colonel Labre, with a large and well-equipped expedition, thirty-four days to accomplish the 161 miles between San Antonio at the foot of the long series of falls, and the town of Villa Bella at the mouth of the Beni. During the overland journey several tribes of Indians were met with, about whom little or nothing is known. The people are mostly Araunas, and seem to have a well-organized social system, with temples and some form of worship. The women, some of them light-coloured, are not allowed to enter the temples. The idols are not of human form, but are geometrical figures made of wood and polished. Several other tribes were met with. The general result of Colonel Labre's expedition was to open up a route of communication between the large towns of the Amazons and the whole of Northern Bolivia, a route which may be extended to Southern Peru by the navigation of the Madre de Dios to the province of Pancastambo and the rich and populous province of Cuzco. Colonel Labre believes that the Purus and its affluents contain about 40,000 indigenes speaking forty or more different languages.

Dr. H. Meyer has arrived at Zanzibar for the purpose of making another attempt to ascend to the highest summit of Kilimanjaro. He will afterwards proceed to explore Mount Kenia.

According to *Petermann's Mitteilungen*, Prof. A. Wichmann has recently returned to Europe from his journey to the Dutch East Indies. On the little island of Samauw, lying off the coast of Timor, he found numerous mud volcanoes. On the island of Rotti, at the south-west end of Timor, he discovered upon the slopes, in two mud volcanoes, some ammonites and belemnites, the first Jurassic fossils which have been found in this archipelago. Prof. Wichmann crossed from Palos, on the island of Celebes, to the Bay of Tomine, on the east coast. The route lay over a mountain range about 3000 feet high, covered with primæval forests, and uninhabited. These mountains are composed of gneiss, crystalline slate, and granite.

M. H. Coudreau recently described to the Paris Geographical Society the results of his last expedition to the Tumuc-Humac Mountains (Guiana), which were only very imperfectly explored by the late M. Crevaux. M. Coudreau effected a survey on the scale of 1 : 100,000 of 2500 miles of route, 1625 miles of which lay along river-courses, and the remaining 875 among the mountains. A complete survey was executed of the courses of the Maroni, Oyapock, and Maroni, from their mouths to their sources. M. Coudreau penetrated into the trackless part of the forest, where a passage had to be hewn out. Measurements were made of 150 summits, and the sources of nearly all the water-courses of both slopes of the range were fixed. The climate of these highlands is healthy, the mean temperature being about 72° F. Immense forests cover a large belt of country at the foot of the mountains. From an ethnographical point of view, M. Coudreau's mission has resulted in the careful study of the manners, customs, and dialects of the score or so of Indian tribes inhabiting this region.

M. Borelli, who for three years has been exploring in the Shoa region and the Galla country, tracing the course of an important River Omo, is convinced that this river falls into Lake Samburu, the Prince Rudolf Lake of Count Teleki; and that therefore the Omo does not belong to the Nile basin, but to an entirely distinct inland lake system, which has no outlet. M. Borelli has brought home hundreds of photographs of the people of the region he has been exploring, and large collections of specimens of the products of the country which will be deposited in the Trocadero.

General Strelbitzky has just published a new edition of his work, "The Superficies of the Russian Empire and the Neighbouring States of Asia." He has incorporated in this edition all the new data, accumulated since 1875, relating to the measurement of the superficies of Russia and her Asiatic possessions. Detailed data as to the superficies of interior seas and lakes, islands, and drainage-areas of separate rivers are added; and the writer presents the first trustworthy information as to the superficies of China, Persia, Afghanistan, Bukhara, Khiva, Corea, and Japan. All figures are given in geographical miles, kilometres, and Russian versts.

AN ATTEMPT TO APPLY TO CHEMISTRY ONE OF THE PRINCIPLES OF NEWTON'S NATURAL PHILOSOPHY.[1]

NATURE, inert to the eyes of the ancients, has been revealed to us as full of life and activity. The conviction that motion pervaded all things, which was first realized with respect to the stellar universe, has now extended to the unseen world of atoms. No sooner had the human understanding denied to the earth a fixed position and launched it along its path in space, than it was sought to fix immovably the sun and the stars. But astronomy has demonstrated that the sun moves with unswerving regularity through the star-set universe at the rate of about 50 kilometres per second. Among the so called fixed stars are now discerned manifold changes and various orders of movement. Light, heat, electricity—like sound—have been proved to be modes of motion; to the realization of this fact modern science is indebted for powers which have been used with such brilliant success, and which have been expounded so clearly at this lecture-table by Faraday and by his successors. As in the imagination of Dante the invisible air became peopled with spiritual beings, so before the eyes of earnest investigators, and especially before those of Clerk Maxwell, the invisible mass of gases became peopled with particles: their rapid movements, their collisions, and impacts became so manifest that it seemed almost possible to count the impacts and determine many of the peculiarities or laws of their collisions. The fact of the existence of these invisible motions may at once be made apparent by demonstrating the difference in the rate of diffusion through porous bodies of the light and rapidly moving atoms of hydrogen and the heavier and more sluggish particles of air. Within the masses of liquid and of solid bodies we have been forced to acknowledge the existence of persistent though limited motion of their ultimate particles, for otherwise it would be impossible to explain, for example, the celebrated experiments of Graham on diffusion through liquid and colloidal substances. If there were, in our times, no belief in the molecular motion in solid bodies, could the famous Spring have hoped to attain any result by mixing carefully dried powders of potash saltpetre, and acetate of soda, in order to produce, by pressure, a chemical reaction between these substances through the interchange of their metals, and have derived, for the conviction of the incredulous, a mixture of two hygroscopic though solid salts—nitrate of soda and acetate of potash?

In these invisible and apparently chaotic movements, reaching from the stars to the minutest atoms, there reigns, however, an harmonious order which is commonly mistaken for complete rest, but which is really a consequence of the conservation of that dynamic equilibrium which was first discerned by the genius of Newton, and which has been traced by his successors in the detailed analysis of the particular consequences of the great generalization,—namely, relative immovability in the midst of universal and active movement.

But the unseen world of chemical changes is closely analogous to the visible world of the heavenly bodies, since our atoms form distinct portions of an invisible world, as planets, satellites, and comets form distinct portions of the astronomer's universe; our atoms may therefore be compared to the solar system, or to the systems of double or of single stars, for example, ammonia (NH_3) may be represented in the simplest manner by supposing the sun nitrogen surrounded by its planets of hydrogen; and common salt ($NaCl$) may be looked upon as a double star formed of nitrogen and chlorine. Besides, now that the indestructibility of the elements has been acknowledged, chemical changes cannot otherwise be explained than as changes of motion, and the production by chemical reactions of galvanic currents, of light, of heat, of pressure, or of steam power, demonstrate visibly that the processes of chemical reaction are inevitably connected with enormous though unseen displacements, originating in the movements of atoms in molecules. Astronomers and natural philosophers, in studying the visible motions of the heavenly bodies and of matter on the earth, have understood and have estimated the value of this store of energy. But the chemist has had to pursue a contrary course. Observing in the physical and mechanical phenomena which accompany chemical reactions the quantity of energy manifested by the atoms and molecules, he is constrained to acknowledge that within the molecules there exist atoms in motion, endowed with an energy which, like matter itself, is neither being created nor is capable of being destroyed. Therefore, in chemistry, we must seek dynamic equilibrium not only between the molecules but also in their midst among their component atoms. Many conditions of such equilibrium have been determined, but much remains to be done, and it is not uncommon, even in these days, to find that some chemists forget that there is the possibility of motion in the interior of molecules, and therefore represent them as being in a condition of death-like inactivity.

Chemical combinations take place with so much ease and rapidity, possess so many special characteristics, and are so numerous, that their simplicity and order was for a long time hid from investigators. Sympathy, relationship, all the caprices or all the fancifulness of human intercourse, seemed to have found complete analogies, in chemical combinations, but with this difference, that the characteristics of the material substances—such as silver, for example, or of any other body—remain unchanged in every subdivision from the largest masses to the smallest particles, and consequently their characteristics must be a property of its particles. But the world of heavenly luminaries appeared equally fanciful at man's first acquaintance with it, so much so that the astrologers imagined a connection between the individualities of men and the conjunctions of planets. Thanks to the genius of Lavoisier and of Dalton, man has been able, in the unseen world of chemical combinations, to recognize laws of the same simple order as those which Copernicus and Kepler proved to exist in the planetary universe. Man discovered, and continues every hour to discover, *what* remains unchanged in chemical evolution, and *how* changes take place in combinations of the unchangeable. He has learned to predict, not only what possible combinations may take place, but also the very existence of atoms of unknown elementary bodies, and has besides succeeded in making innumerable practical applications of his knowledge, to the great advantage of his race, and has accomplished this notwithstanding that notions of sympathy and affinity still preserve a strong vitality in science. At present we cannot apply Newton's principles to chemistry, because the soil is only being now prepared. The invisible world of chemical atoms is still waiting for the creator of chemical mechanics. For him our age is collecting a mass of materials, the inductions of well-digested facts, and many-sided inferences similar to those which existed for astronomy and mechanics in the days of Newton. It is well also to remember that Newton devoted much time to chemical experiments, and while considering questions of celestial mechanics, persistently kept in view the mutual action of those infinitely small worlds which are concerned in chemical evolutions. For this reason, and also to maintain the unity of laws, it seems to me that we must, in the first instance, seek to harmonize the various phases of contemporary chemical theories with the immortal principles of the Newtonian natural philosophy, and so hasten the advent of true chemical mechanics. Let the above considerations serve as my justification for the attempt which I propose to make to act as a champion of the universality of the Newtonian principles, which I believe are competent to embrace every phenomenon in the universe, from the rotation of the fixed stars, to the interchanges of chemical atoms.

In the first place, I consider it indispensable to bear in mind that, up to quite recent times, only a one-sided affinity has been recognized in chemical reactions. Thus, for example, from the circumstance that red-hot iron decomposes water with the evolution of hydrogen, it was concluded that oxygen had a greater affinity for iron than for hydrogen. But hydrogen, in presence of red-hot iron scale, appropriates its oxygen, and forms water, whence an exactly opposite conclusion may be formed.

During the last ten years a gradual, scarcely perceptible, but most important change has taken place in the views, and consequently in the researches, of chemists. They have sought everywhere, and have always found systems of conservation or dynamic equilibrium substantially similar to those which natural philosophers have long since discovered in the visible world, and in virtue of which the position of the heavenly bodies in the universe is determined. There, where one-sided affinities only were at first detected, not only secondary or lateral ones have been found, but even those which are diametrically opposite, yet among these, dynamical equilibrium establishes itself, not by excluding one or other of the forces, but regulating them all. So the chemist finds in the flame of the blast-furnace, in the formation of every salt, and, with especial clearness, in double salts, and in the crystallization of solutions, not a fight ending in the victory of one side, as used to be supposed, but the conjunction of forces; the peace of dynamic equilibrium resulting

[1] The Friday evening lecture delivered at the Royal Institution of Great Britain, on May 31, 1889, by Prof. D. Mendeleeff, Professor of Chemistry in the University of St. Petersburg.

from the action of many forces and affinities. Carbonaceous matters, for example, burn at the expense of the oxygen of the air, yielding a quantity of heat and forming products of combustion, in which it was thought that the affinities of the oxygen with the combustible elements were satisfied. But it appeared that the heat of combustion was competent to decompose these products, to dissociate the oxygen from the combustible elements; and therefore, to explain combustion fully, it is necessary to take into account the equilibrium between opposite reactions, between those which evolve and those which absorb heat.

In the same way, in the case of the solution of common salt in water, it is necessary to take into account, on the one hand, the formation of compound particles generated by the combination of salt with water, and, on the other, the disintegration or scattering of the new particles formed, as well as of those originally contained. At present we find two currents of thought, apparently antagonistic to each other, dominating the study of solutions: according to the one, solution seems a mere act of building up or association; according to the other, it is only dissociation or disintegration. The truth lies, evidently, between these views; it lies, as I have endeavoured to prove by my investigations into aqueous solutions, in the dynamic equilibrium of particles tending to combine and also to fall asunder. The large majority of chemical reactions which appeared to act victoriously along one line have been proved capable of acting as victoriously even along an exactly opposite line. Elements which utterly decline to combine directly may often be formed into comparatively stable compounds by indirect means, as, for example, in the case of chlorine and carbon; and, consequently, the sympathies and antipathies, which it was thought to transfer from human relations to those of atoms, should be laid aside until the mechanism of chemical relations is explained. Let us remember, however, that chlorine, which does not form with carbon the chloride of carbon, is strongly absorbed, or, as it were, dissolved by carbon, which leads us to suspect incipient chemical action even in an external and purely surface contact, and involuntarily gives rise to conceptions of that unity of the forces of Nature which has been so energetically insisted on by Sir William Grove and formulated in his famous paradox. Grove noticed that platinum, when fused in the oxyhydrogen flame, during which operation water is formed, when allowed to drop into water decomposes the latter and produces the explosive oxyhydrogen mixture. The explanation of this paradox, as of many others which arose during the period of chemical renaissance, has led, in our time, to the promulgation by Henri St. Claire Deville of the conception of dissociation and of equilibrium, and has recalled the teaching of Berthollet, which, notwithstanding its brilliant confirmation by Heinrich Rose and Dr. Gladstone, had not, up to that period, been included in received chemical views.

Chemical equilibrium in general, and dissociation in particular, are now being so fully worked out in detail, and applied in such various ways, that I do not allude to them to develop, but only use them as examples by which to indicate the correctness of a tendency to regard chemical combinations from points of view differing from those expressed by the term hitherto appropriated to define chemical forces—namely, "affinity." Chemical equilibria dissociation, the speed of chemical reactions, thermo-chemistry, spectroscopy, and, more than all, the determination of the influence of masses and the search for a connection between the properties and weights of atoms and molecules; in one word, the vast mass of the most important chemical researches of the present day, clearly indicates the near approach of the time when chemical doctrines will submit fully and completely to the doctrine which was first announced in the "Principia" of Newton.

In order that the application of these principles may bear fruit, it is evidently insufficient to assume that statical equilibrium reigns alone in chemical systems or chemical molecules: it is necessary to grasp the conditions of possible states of dynamical equilibria, and to apply to them kinetic principles. Numerous considerations compel us to renounce the idea of statical equilibrium in molecules, and the recent yet strongly supported appeals to dynamic principles constitute, in my opinion, the foundation of the modern teaching relating to atomicity, or the valency of the elements, which usually forms the basis of investigations into organic or carbon compounds.

This teaching has led to brilliant explanations of very many chemical relations and to cases of isomerism, or the difference in the properties of substances having the same composition. It has been so fruitful in its many applications and in the foreshadowing of remote consequences, especially respecting carbon compounds, that it is impossible to deny its claims to be ranked as a great achievement of chemical science. Its practical application to the synthesis of many substances of the most complicated composition entering into the structure of organized bodies, and to the creation of an unlimited number of carbon compounds, among which the colours derived from coal tar stand prominently forward, surpass the synthetical powers of Nature itself. Yet this teaching, as applied to the structure of carbon compounds, is not on the face of it directly applicable to the investigation of other elements, because in examining the first it is possible to assume that the atoms of carbon have always a definite and equal number of affinities, while in the combinations of other elements this is evidently inadmissible. Thus, for example, an atom of carbon yields only one compound with four atoms of hydrogen and one with four atoms of chlorine in the molecule, while the atoms of chlorine and hydrogen unite only in the proportions of one to one. Simplicity is here evident, and forms a point of departure from which it is easy to move forward with firm and secure tread. Other elements are of a different nature. Phosphorus unites with three and with five atoms of chlorine, and consequently the simplicity and sharpness of the application of structural conceptions are lost. Sulphur unites only with two atoms of hydrogen, but with oxygen it enters into higher orders of combination. The periodic relationship which exists among all the properties of the elements, such, for example, as their ability to enter into various combinations, and their atomic weights, indicate that this variation in atomicity is subject to one perfectly exact and general law, and it is only carbon and its near analogues which constitute cases of permanently preserved atomicity. It is impossible to recognize as constant and fundamental properties of atoms, powers which, in substance, have proved to be variable. But by abandoning the idea of permanence, and of the constant saturation of affinities—that is to say, by acknowledging the possibility of free affinities—many retain a comprehension of the atomicity of the elements "under given conditions"; and on this frail foundation they build up structures composed of chemical molecules, evidently only because the conception of manifold affinities gives, at once, a simple statical method of estimating the composition of the most complicated molecules.

I shall enter neither into details, nor into the various consequences following from these views, nor into the disputes which have sprung up respecting them (and relating especially to the number of isomers possible on the assumption of free affinities), because the foundation or origin of theories of this nature suffers from the radical defect of being in opposition to dynamics. The molecule, as even Laurent expressed himself, is represented as an architectural structure, the style of which is determined by the fundamental arrangement of a few atoms, while the decorative details, which are capable of being varied by the same forces, are formed by the elements entering into the combination. It is on this account that the term "structural" is so appropriate to the contemporary views of the above order, and that the "constructors" seek to justify the tetrahedric, plane, or prismatic disposition of the atoms of carbon in benzole. It is evident that the consideration relates to the statical position of atoms and molecules, and not to their kinetic relations. The atoms of the structural type are like the lifeless pieces on a chess-board: they are endowed but with the voices of living beings, and are not those living beings themselves; acting, indeed, according to laws, yet each possessed of a store of energy, which, in the present state of our knowledge, must be taken into account.

In the days of Haüy, crystals were considered in the same statical and structural light, but modern crystallographers, having become more thoroughly acquainted with their physical properties and their actual formation, have abandoned the earlier views and have made their doctrines dependent on dynamics.

The immediate object of this lecture is to show that, starting with Newton's third law of motion, it is possible to preserve to chemistry all the advantages arising from structural teaching, without being obliged to build up molecules in solid and motionless figures, or to ascribe to atoms definite limited valencies, directions of cohesion, or affinities. The wide extent of the subject obliges me to treat only a small portion of it—namely, of *substitutions*, without specially considering combinations and decompositions—and, even then, limiting myself to the simplest examples, which, however, will throw open prospects embracing all the natural complexity of chemical relations. For this reason, if it should prove possible to form groups similar, for example, to H_4 or CH_6 as the remnants of molecules CH_4 or C_2H_6, we shall not pause to consider them, because, as far as we know, they fall asunder into two parts, $H_2 + H_2$ or $CH_4 + H_2$, as soon as they are even temporarily formed, and are capable of separate existence, and therefore can take no part in the elementary act of substitution. With respect to the simplest molecules which we shall select—that is to say, those of which the parts have no separate existence, and therefore cannot appear in substitutions—we shall consider them according to the periodic law, arranging them in direct dependence on the atomic weight of the elements.

Thus, for example, the molecules of the simplest hydrogen compounds—

HF	H_2O	H_3N	H_4C
Hydrofluoric acid	Water	Ammonia	Methane

correspond to elements the atomic weights of which decrease consecutively—

$$F = 19, \ O = 16, \ N = 14, \ C = 12.$$

Neither the arithmetical order (1, 2, 3, 4 atoms of hydrogen) nor the total information we possess respecting the elements will permit us to interpolate into this typical series one more additional element; and therefore we have here, for hydrogen compounds, a natural base upon which are built up those simple chemical combinations which we take as typical. But even they are competent to unite with each other, as we see, for instance, in the property which hydrofluoric acid has of forming a hydrate—that is, of combining with water; and the similar attribute of ammonia, resulting in the formation of a caustic alkali, NH_3H_2O, or NH_4OH.

Having made these indispensable preliminary observations, I may now attack the problem itself, and attempt to explain the so-called structure, or rather construction of molecules—that is to say, their constitution and transformations—without having recourse to the teaching of "structionists," but on Newton's dynamical principles.

Of Newton's three laws of motion, only the third can be applied directly to chemical molecules when regarded as systems of atoms among which it must be supposed that there exist common influences or forces, and resulting compounded relative motions. Chemical reactions of every kind are undoubtedly accomplished by changes in these internal movements, respecting the nature of which nothing is known at present, but the existence of which the mass of evidence collected in modern times forces us to acknowledge as forming part of the common motion of the universe, and as a fact further established by the circumstance that chemical reactions are always characterized by changes of volume or the relations between the atoms or the molecules. Newton's third law, which is applicable to every system, declares that "action is always associated with reaction, and is equal to it." The brevity and conciseness of this axiom was, however, qualified by Newton in a more expanded statement: "The actions of bodies one upon another are always equal, and in opposite directions." This simple fact constitutes the point of departure for explaining dynamic equilibrium—that is to say, systems of conservancy. It is capable of satisfying even the dualists, and of explaining, without additional assumptions, the preservation of those chemical types which Dumas, Laurent, and Gerhardt created unit types, and those views of atomic combinations which the structionists express by atomicity or the valency of the elements, and, in connection with them, the various numbers of affinities. In reality, if a system of atoms or a molecule be given, then in it, according to the third law of Newton, each portion of atoms acts on the remaining portion in the same manner and with the same force as the second set of atoms acts on the first. We infer directly from this consideration that both sets of atoms forming a molecule are not only equivalent with regard to themselves, as they must be according to Dalton's law, but also that they may, if united, replace each other. Let there be a molecule containing atoms A B C, it is clear that, according to Newton's law, the action of A on B C must be equal to the action of B C on A, and if the first action is directed on B C, then the second must be directed on A, and consequently then, where A can exist in dynamic equilibrium, B C may take its place and act in a like manner. In the same way the action of C is equal to the action of A B. In one word every two sets of atoms forming a molecule are equivalent to each other, and may take each other's place in other molecules, or, having the power of balancing each other, the atoms or their complements are endowed with the power of replacing each other. Let us call this consequence of an evident axiom "the principle of substitution," and let us apply it to those typical forms of hydrogen compounds which we have already discussed, and which, on account of their simplicity and regularity, have served as starting-points of chemical argument long before the appearance of the doctrine of structure.

In the type of hydrofluoric acid, HF, or in systems of double stars, are included a multitude of the simplest molecules. It will be sufficient for our purpose to recall a few: for example, the molecules of chlorine, Cl_2, and of hydrogen, H_2, and hydrochloric acid, HCl, which is familiar to all in aqueous solution as spirit of salt, and which has many points of resemblance with HF, HB_2, HI. In these cases division into two parts can only be made in one way, and therefore the principle of substitution renders it probable that exchanges between the chlorine and the hydrogen can take place, if they are competent to unite with each other. There was a time when no chemist would even admit the idea of any such action; it was then thought that the power of combination indicated a polar difference of the molecules in combination, and this thought set aside all idea of the substitution of one component element by another.

Thanks to the observations and experiments of Dumas and Laurent fifty years ago, such fallacies were dispelled, and in this manner this same principle of substitution was exhibited. Chlorine and bromine, acting on many hydrogen compounds, occupy immediately the place of their hydrogen, and the displaced hydrogen, with another atom of chlorine or bromine, forms hydrochloric acid or bromide of hydrogen. This takes place in all typical hydrogen compounds. Thus chlorine acts on this principle on gaseous hydrogen—reaction, under the influence of light, resulting in the formation of hydrochloric acid. Chlorine, acting on the alkalies, constituted similarly to water, and even on water itself—only, however, under the influence of light, and only partially because of the instability of HClO—forms, by this principle, bleaching salts, which are the same as the alkalies, but with their hydrogen replaced by chlorine. In ammonia and in methane, chlorine can also replace the hydrogen. From ammonia is formed in this manner the so-called chloride of nitrogen, NCl_3, which decomposes very readily with violent explosion on account of the evolved gases, and falls asunder as chlorine and nitrogen. Out of marsh gas, or methane, CH_4, may be obtained consecutively, by this method, every possible substitution, of which chloroform, $CHCl_3$, is the best known, and chloro-carbonic acid, CCl_4, the most instructive. But by virtue of the fact that chlorine and bromine act in the manner shown on the simplest typical hydrogen compounds, their action on the more complicated ones may be assumed to be the same. This can be easily demonstrated. The hydrogen of benzole, C_6H_6, reacts feebly under the influence of light on liquid bromine, but Gustavson has shown that the addition of the smallest quantity of metallic aluminium causes energetic action, and the evolution of large volumes of bromide of hydrogen.

If we pass on to the second typical hydrogen compound—that is to say, water—its molecule, HOH, may be split up in two ways: either into an atom of hydrogen and a molecule of oxide of hydrogen, HO, or into oxygen, O, and two atoms of hydrogen, H; and therefore, according to the principle of substitution, it is evident that one atom of hydrogen can exchange with oxide of hydrogen, HO, and two atoms of hydrogen, H, with one atom of oxygen, O.

Both these forms of substitution will constitute methods of oxidation—that is to say, of the entrance of oxygen into the compound—a reaction which is so common in Nature as well as in the arts, taking place at the expense of the oxygen of the air or by the aid of various oxidizing substances or bodies which part easily with their oxygen. There is no occasion to reckon up the unlimited number of cases of such oxidizing reactions. It is sufficient to state that, in the first of these, oxygen is directly transferred, and the position, the chemical function, which hydrogen originally occupied is, after the substitution, occupied by the hydroxyl. Thus ammonia, NH_3, yields hydroxylamine, $NH_2(OH)$, a substance which retains many of the properties of ammonia.

Methane and a number of other hydrocarbons yield, by substitution of the hydrogen by its oxide, methylic, $CH_3(OH)$, and other alcohols. The substitution of one atom of oxygen for two atoms of hydrogen is equally common with hydrogen compounds. By this means alcoholic liquids containing ethyl alcohol, or spirits of wine, $C_2H_5(OH)$, are oxidized till they become vinegar or acetic acid, $C_2H_3O(OH)$. In the same way caustic ammonia, or the combination of ammonia with water, NH_3H_2O, or $NH_4(OH)$, which contains a great deal of hydrogen, by oxidation exchanges four atoms of hydrogen for two atoms of oxygen, and becomes converted into nitric acid, $NO_2(OH)$. This process of conversion of ammonia salts into saltpetre goes on in the fields every summer, and with especial rapidity in tropical countries. The method by which this is accomplished, though complex, though involving the agency of all-permeating micro-organisms, is, in substance, the same as that by which alcohol is converted into acetic acid, or glycol, $C_2H_4(OH)_2$ into oxalic acid, if we view the process of oxidation in the light of the Newtonian principles.

But while speaking of the application of the principle of substitution to water, we need not multiply instances, but must turn our attention to two special circumstances which are closely connected with the very mechanism of substitutions.

In the first place, the replacement of two atoms of hydrogen by one atom of oxygen may take place in two ways, because the hydrogen molecule is composed of two atoms, and therefore, under the influence of oxygen, the molecule forming water may separate before the oxygen has time to take its place. It is for this reason that we find, during the conversion of alcohol into acetic acid, that there is an interval during which is formed aldehyde, C_2H_4O, which, as its very name implies, is "alcohol dehydrogenatum," or alcohol deprived of hydrogen. Hence aldehyde combined with hydrogen yields alcohol, and, united to oxygen, acetic acid.

For the same reason there should be, and there actually are, intermediate products between ammonia and nitric acid, $NO_2(HO)$, containing either less hydrogen than ammonia, less oxygen than nitric acid, or less water than caustic ammonia. Accordingly we find, among the products of the de-oxidization of nitric acid and the oxidization of ammonia, not only hydroxylamine, but also nitrous oxide, nitrous and nitric anhydrides. Thus, the production of nitrous acid results from the removal of two atoms of hydrogen from caustic ammonia and the substitution of the oxygen for the hydrogen, $NO(OH)$; or by the substitution, in ammonia, of three atoms of hydrogen by hydroxyl, $N(OH)_3$, and by the removal of water; $N(OH)_3—H_2O = NO(OH)$. The peculiarities and properties of nitrous acid, as, for instance, its action on ammonia and its conversion, by oxidation, into nitric acid, are thus clearly revealed.

On the other hand, in speaking of the principle of substitution as applied to water, it is necessary to observe that hydrogen and hydroxyl, H and OH, are not only competent to unite, but also to form combinations with themselves, and thus become H_2 and H_2O_2; and such are hydrogen and the peroxide thereof. In general, if a molecule AB exists, then molecules AA and BB can exist also. A direct reaction of this kind does not, however, take place in water, therefore undoubtedly, at the moment of formation hydrogen reacts on the peroxide of hydrogen, as we can show at once by experiment; and further, because the peroxide of hydrogen, H_2O_2, exhibits a structure containing a molecule of hydrogen, H_2, and one of oxygen, O_2, either of which is capable of separate existence. The fact, however, may now be taken as thoroughly established, that, at the moment of combustion of hydrogen or of the hydrogen compounds, peroxide of hydrogen is always formed, and not only so, but in all probability its formation invariably precedes the formation of water. This was to be expected as a consequence of the law of Avogadro and Gerhardt, which leads us to expect this sequence in the case of equal interactions of volumes of vapours and gases; and in the peroxide of hydrogen we actually have such equal volumes of the elementary gases.

The instability of peroxide of hydrogen—that is to say, the ease with which it decomposes into water and oxygen, even at the mere contact of porous bodies—accounts for the circumstance that it does not form a permanent product of combustion, and is not produced during the decomposition of water. I may mention this additional consideration that, with respect to the peroxide of hydrogen, we may look for its effecting still further substitutions of hydrogen by means of which we may expect to obtain still more highly oxidized water-compounds, such as H_2O_3 and H_2O_4. These, Schönbein and Bunsen have long been seeking, and Berthelot is investigating them at this moment. It is probable, however, that the reaction will stop at the last compound, because we find that in a number of cases the addition of four atoms of oxygen seems to form a limit. Thus, OsO_4, $KClO_4$, $KMnO_4$, K_2SO_4, Na_3PO_4, and such like, represent the highest grades of oxidation.[1]

As for the last forty years, from the times of Berzelius, Dumas, Liebig, Gerhardt, Williamson, Frankland, Kolbe, Kekulé, and Butlerow, most theoretical generalizations have centred round organic or carbon compounds, so we will, for the sake of brevity, leave out the discussion of ammonia derivatives, notwithstanding their simplicity in respect to the doctrine of substitutions; we will dwell more especially on its application to carbon compounds, starting from methane, CH_4, as the simplest of the hydrocarbons, containing in its molecule one atom of carbon. According to the principles enumerated, we may derive from CH_4 every combination of the form CH_3X, CH_2X_2, CHX_3, and CX_4, in which X is an element, or radical, equivalent to hydrogen—that is to say, competent to take its place or to combine with it. Such are the chlorine substitutes mentioned already, such is wood-spirit, $CH_3(OH)$, in which X is represented by the residue of water, and such are numerous other carbon derivatives. If we continue, with the aid of hydroxyl, further substitutions of the hydrogen of methane, we shall obtain successively $CH_2(OH)_2$, $CH(OH)_3$, and $C(OH)_4$. But if, in proceeding thus, we bear in mind that $CH_2(OH)_2$ contains two hydroxyls in the same form as peroxide of hydrogen, H_2O_2 or $(OH)_2$, contains them—and, moreover, not only in one molecule, but together, attached to one and the same atom of carbon—so here we must look for the same decomposition as that which we find in peroxide of hydrogen, and accompanied also by the formation of water as an independently existing molecule; therefore $CH_2(OH)_2$ should yield, as it actually does, immediately water and the oxide of methylene, CH_2O, which is methane with oxygen substituted for two atoms of hydrogen. Exactly in the same manner out of $CH(OH)_3$ are formed water and formic acid, $CHO(OH)$, and out of $C(OH)_4$ is produced water and carbonic acid, or directly carbonic anhydride, CO_2, which will therefore be nothing else than methane with the double replacement of pairs of hydrogen by oxygen. As nothing leads to the supposition that the four atoms of hydrogen in methane differ one from the other, so it does not matter by what means we obtain any one of the combinations indicated—they will be identical; that is to say, there will be no case of actual isomerism, although there may easily be such cases of isomerism as have been distinguished by the term metamerism.

Formic acid, for example, has two atoms of hydrogen, one attached to the carbon left from the methane, and the other attached to the oxygen which has entered in the form of hydroxyl, and if one of them be replaced by some substance, X, it is evident that we shall obtain bodies of the same composition, but of different construction, or of dfferent orders of movement among the molecules, and therefore endowed with other properties and reactions. If X be methyl, CH_3—that is to say, a group capable of replacing hydrogen because it is actually contained with hydrogen in methane itself—then by substituting this group for the original hydrogen, we obtain acetic acid, $CCH_3O(OH)$, out of formic, and by substitution of the hydrogen in its oxide or hydroxyl, we obtain methyl formiate, $CHO(OCH_3)$. These bodies differ so much from each other physically and chemically that, at first sight, it is hardly possible to admit that they contain the same atoms in identically the same proportions. Acetic acid, for example, boils at a higher temperature than water, and has a higher specific gravity than it, while its metamer, formo-methylic ether, is lighter than water, and boils at 30°—that is to say, it evaporates very easily.

Let us now turn to carbon compounds containing two atoms

[1] Because more than four atoms of hydrogen never unite with one atom of the elements, and because the hydrogen compounds (*e.g.* HCl, H_2S, H_3P, H_4Si) always form their highest oxides with four atoms of oxygen, and as the highest forms of oxides (OSO_4RO_4) also contain four of oxygen, and eight groups of the periodic system, corresponding to the highest basic oxides R_2O, RO, R_2O_3, RO_2, R_2O_5, RO_3, R_2O_7, and RO_4, imply the above relationship, and because of the nearest analogues among the elements—such as Mg, Zn, Cd, and Hg; or Cr, Mo, W, and U; or Si, Ge, Sn, and Pt; or F, Cl, Br, and J, and so forth—not more than four are known, it seems to me that in these relationships there lies a deep interest and meaning with regard to chemical mechanics. But because, to my imagination, the idea of unity of design in Nature, either acting in complex celestial systems or among chemical molecules, is very attractive, especially because the atomic teaching at once acquires its true meaning, I will recall the following facts relating to the solar system. There are eight major planets, of which the four inner ones are not only separated from the four outer by asteroids, but differ from them in many respects, as, for example, in the smallness of their diameters and their greater density. Saturn with his ring has eight satellites, Jupiter and Uranus have each four. It is evident that in the solar systems also we meet with these higher numbers, four and eight, which appear in the combination of chemical molecules.

of carbon to the molecule, as in acetic acid, and proceed to evolve them from methane by the principle of substitution. This principle declares at once that methane can only be split up in the four following ways:—

(1) Into a group CH_3 equivalent with H. Let us call changes of this nature methylation.

(2) Into a group CH_2 and H_2. We will call this order of substitutions methylenation.

(3) Into CH and H_3, which commutations we will call acetylenation.

(4) Into C and H_4, which may be called carbonization.

It is evident that hydrocarbon compounds containing two atoms of carbon can only proceed from methane, CH_4, which contains four atoms of hydrogen by the first three methods of substitution: carbonizing would yield free carbon if it could take place directly, and if the molecule of free carbon—which is in reality very complex, that is to say, strongly polyatomic, as I have long since been proving by various means—could contain only C_2 like the molecules O_2, H_2, N_2, and so on.

By methylation, we should evidently obtain from marsh gas, ethane, $CH_3CH_3 = C_2H_6$.

By methylenation, that is, by substituting group CH_2 for H_2, methane forms ethylene, $CH_2CH_2 = C_2H_4$.

By acetylenation, that is, by substituting three atoms of hydrogen, H_3, in methane, by the remnant CH, we get acetylene $CHCH = C_2H_2$.

If we have applied the principles of Newton correctly, there should not be any other hydrocarbons containing two atoms of carbon in the molecule. All these combinations have long been known, and in each of them we can not only produce those substitutions of which an example has been given in the case of methane, but also all the phases of other substitutions, as we shall find from a few more instances, by the aid of which I trust that I shall be able to show the great complexity of those derivatives which, on the principle of substitution, can be obtained from each hydrocarbon. Let us content ourselves with the case of ethane, CH_3CH_3, and the substitution of the hydrogen by hydroxyl. The following are the possible changes:—

(1) $CH_3CH_2(OH)$: this is nothing more than spirit of wine, or ethyl alcohol, $C_2H_5(OH)$, or C_2H_6O.

(2) $CH_2(OH)CH_2(OH)$: this is the glycol of Wurtz, which has shed so much light on the history of alcohol. Its isomer may be $CH_3CH(OH)_2$, but as we have seen in the case of $CH(OH)_3$, it decomposes, giving off water, and forming aldehyde, CH_3CHO, a body capable of yielding alcohol by uniting with hydrogen and of yielding acetic acid by uniting with oxygen.

If glycol $CH_2(OH)CH_2(OH)$ loses its water, it may be seen at once that it will not now yield aldehyde, CH_3CHO, but its isomer, $\underset{O}{CH_2CH_2}$, the oxide of ethylene. I have here indicated in a special manner the oxygen which has taken the place of two atoms of the hydrogen of ethane taken from different atoms of the carbon.

(3) $CH_3C(OH)_3$ decomposed as $CH(OH)_3$, forming water and acetic acid, $OH_3CO(OH)$. It is evident that this acid is nothing else than formic acid, $CHO(OH)$, with its hydrogen replaced by methyl. Without examining further the vast number of possible derivatives, I will direct your attention to the circumstance that in dissolving acetic acid in water we obtain the maximum contraction, and the greatest viscosity when to the molecule $CH_3CO(OH)$ is added a molecule of water, which is the proportion which would form the hydrate $CH_3C(OH)_3$. It is probable that the doubling of the molecule of acetic acid at temperatures approaching its boiling-point has some connection with this power of uniting with one molecule of water.

(4) $CH^2(OH)C(OH)^3$ is evidently alcoholic acid, and indeed this compound, after losing water, answers to glycolic acid, $CH_2(OH)CO(OH)$. Without investigating all the possible isomers, we will note only that the hydrate $CH(OH)_2CH(OH)_2$ has the same composition as $CH_2(OH)C(OH)_3$, and although corresponding to glycol, and being a symmetrical substance, it becomes, on parting with its water, aldehyde of oxalic acid, or the glyoxal of Debus, $CHOCHO$.

(5) $CH(OH)_2C(OH_3)$, from the tendency of all the preceding, coresponds to glyoxylic acid, aldehyde acid, $CHOCO(OH)$, because the group $CO(OH)$, or carboxyl, enters into the compositions of organic acids, and the group CHO defines the aldehyde function.

(6) $C(OH)_3C(OH)_3$, through the loss of $2H_2O$, yields the bibasic oxalic acid $CO(OH)CO(OH)$, which generally crystallizes with $2H_2O$, following thus the normal type of hydration characteristic of ethane.[1]

Thus, by applying the principle of substitution, we can, in the simplest manner, derive not only every kind of hydrocarbon compound, such as the alcohols, the aldehyde alcohols, aldehydes, alcohol acids, and the acids, but also combinations analogous to hydrated crystals which usually are disregarded.

But even these unsaturated substances, of which ethylene, CH_2CH_2, and acetylene, CHCH, are types, may be evolved with equal simplicity. With respect to the phenomena of isomerism, there are many possibilities among the hydrocarbon compounds containing two atoms of carbon, and without going into details it will be sufficient to indicate that the following formulæ, though not identical, will be isomeric substantially among themselves: CH_3CHX_2 and CH_2XCH_2X, although both contain $C_2H_4X_2$, or CH_3CX_2 and CHXCHX, although both contain $C_2H_2X_2$, if by X we indicate chlorine or generally an element capable of replacing one atom of hydrogen, or capable of uniting with it. To isomerism of this kind belongs the case of aldehyde and the oxide of ethylene, to which we have already referred, because both have the composition C_2H_4O.

What I have said appears to me sufficient to show that the principle of substitution adequately explains the composition, the isomerism and all the diversity of combination of the hydrocarbons, and I shall limit the further development of these views to preparing a complete list of every possible hydrocarbon compound containing three atoms of carbon in the molecule. There are eight in all, of which only five are known at present.[2]

Among those possible for C_3H_6 there should be two isomers, propylene and trimethylene, and they are both already known. For C_3H_4 there should be three isomers: allylene and allene are known, but the third has not yet been discovered; and for C_3H_2 there should be two isomers, though neither of them are known as yet. Their composition and structure is easily deduced from ethane, ethylene, and acetylene, by methylation, methylenation, by acetylenation and by carbonization.

(1) $C_3H_8 = CH_3CH_2CH_3$ out of CH_3CH_3 by methylation. This hydrocarbon is named propane.

(2) $C_3H_6 = CH_3CHCH_2$ out of CH_3CH_3 by methylenation. This substance is propylene.

(3) $C_3H_6 = CH_2CH_2CH_2$ out of CH_3CH_3 by methylenation. This substance is trimethylene.

(4) $C_3H_4 = CH_3CCH$ out of CH_3CH_3 by acetylenation or from CHCH by methylation. This hydrocarbon is named allylene.

(5) $C_3H_4 = \underset{CH_2}{CHCH}$ out of CH_3CH_3 by acetylenation, or from CH_2CH_2 by methylenation, because $\underset{CH}{CH_2CH} = \underset{CH_2}{CHCH}$. This body is as yet unknown.

(6) $C_3H_4 = CH_2CCH_2$ out of CH_2CH_2 by methylenation. This hydrocarbon is named allene, or iso-allylene.

(7) $C_3H_2 = \underset{C}{CHCH}$ out of CH_3H_3 by symmetrical carbonization, or out of CH_2CH_2 by acetylenation. This compound is unknown.

(8) $C_3H_2 = \underset{CH_2}{CC}$ out of CH_3CH_3 by carbonization, or out of CHCH by methylenation. This compound is unknown.

[1] One more isomer, $CH_2CH(OH)$, is possible, that is secondary vinyl alcohol, which is related to ethylene, CH_2CH_2, but derived by the principle of substitution from CH_4. Other isomers of the composition C_2H_4O, such, for example, as $CHCH_3(OH)$, are impossible, because it would correspond to the hydrocarbon $CHCH_3 = C_2H_4$, which is isomeric with ethylene, and it cannot be derived from methane. If such an isomer existed, it would be derived from CH_2, but such products are up to the present unknown. In such cases the insufficiency of the points of departure of the statical structural teaching is shown. It first admits constant atomicity, and then rejects it, the facts serving to establish either one or the other view; and therefore, it seems to me that we must come to the conclusion that the structural method of reasoning, having done a service to science, has outlived the age, and must be regenerated, as, in their time, was the teaching of the electro-chemists, the radicalists, and the adherents of the doctrine of types. As we cannot now lean on the views above stated, it is time to abandon the structural theory. They will all be united in chemical mechanics, and the principle of substitution must be looked upon only as a preparation for the coming epoch in chemistry, where such cases as the isomerism of fumaric and maleic acids, when explained dynamically, as proposed by Le Bel and Van 't Hoff, may yield points of departure.

[2] Conceding variable atomicity, the structurists must expect an incomparably larger number of isomers, and they cannot now decline to acknowledge the change of atomicity, were it only for the examples HgCl and $HgCl_2$, CO and CO_2, PCl_3 and PCl_5.

If we bear in mind that for each hydrocarbon serving as a type in the above tables there are a number of corresponding derivatives, and that every compound obtained may, by further methylation, methylenation, acetylenation, and carbonization, produce new hydrocarbons, and these may be followed by a numerous suite of derivatives and an immense number of isomeric bodies, it is possible to understand the limitless number of carbon compounds, although they all have the one substance, methane, for their origin. The number of substances is so enormous, that it is no longer a question of enlarging the possibilities of discovery, but rather of finding some means of testing them, analogous to the well-known two which for a long time have served as gauges for all carbon compounds.

I refer to the law of even numbers and to that of limits, the first enunciated by Gerhardt forty years ago, with respect to hydrocarbons—namely, that their molecules always contain an even number of atoms of hydrogen. But by the method which I have used of deriving all the hydrocarbons from methane, CH_4, this law may be deduced as a direct consequence of the principle of substitutions. Accordingly, in methylation, CH_3 takes the place of H, and therefore CH_2 is added. In methylenation the number of atoms of hydrogen remains unchanged, and at each acetylenation it is reduced by two, and in carbonization by four atoms—that is to say, an even number of atoms of hydrogen is always added or removed. And because the fundamental hydrocarbon, methane, CH_4, contains an even number of atoms of hydrogen, therefore all its derivative hydrocarbons will also contain even numbers of hydrogen, and this constitutes the law of even numbered parts.

The principle of substitutions explains with equal simplicity the conception of limiting compositions of hydrocarbons, C_nH_{2n+2}, which I derived, in 1861,[1] in an empirical manner from accumulated materials available at that time, and on the basis of the limits to combinations worked out by Dr. Frankland for other elements.

Of all the various substitutions the highest proportion of hydrogen is yielded by methylation, because in that operation alone does the quantity of hydrogen increase; therefore, taking methane as a point of departure, if we imagine methylation effected $(n-1)$ times we obtain hydrocarbon compounds containing [the highest quantities of hydrogen. It is evident that they will contain

$$CH_4+(n-1)\,CH_2, \text{ or } C_nH_{2n+2},$$

because methylation leads to the addition of CH_2 to the compound.

It will thus be seen that by the principle of substitution—that is to say, by the third law of Newton—we are able to deduce, in the simplest manner, not only the individual composition, the somerism, and relations of substances, but also the general laws which govern their most complex combinations, without having recourse either to statical constructions, to the definition of atomicities, to the exclusion of free affinities, or to the recognition of those single, double, or treble ties which are so indispensable to structurists in the explanation of the composition and construction of hydrocarbon compounds. And yet, by the application of the dynamic principles of Newton, we can attain to that chief and fundamental object—the comprehension of isomerism in hydrocarbon compounds, and the forecasting of the existence of combinations as yet unknown, by which the edifice raised by structural teaching is strengthened and supported. Besides, and I count this for a circumstance of special importance, the process which I advocate will make no difference in those special cases which have been already so well worked out, such as, for example, the isomerism of the hydrocarbons and alcohols, even to the extent of not interfering with the nomenclature which has been adopted, and the structural system will retain all the glory of having worked up, in a thoroughly scientific manner, the store of information which Gerhardt had accumulated about the middle of the fifties, and the still higher glory of establishing the rational synthesis of organic substances. Nothing will be lost to the structural doctrine, except its statical origin; and as soon as it will embrace the dynamic principles of Newton, and suffer itself to be guided by them, I believe that we shall attain, for chemistry, that unity of principle which is now wanting. Many an adept will be attracted to that brilliant and fascinating enterprise, the penetration into the unseen world of the kinetic relations of atoms, to the study of which the last twenty-five years have contributed so much labour and such high inventive faculties.

D'Alembert found in mechanics, that if inertia be taken to represent force, dyamic equations may be applied to statical questions which are thereby rendered more simple and more easily understood.

The structural doctrine in chemistry has unconsciously followed the same course, and therefore its terms are easily adopted; they may retain their present forms provided that a truly dynamical—that is to say, Newtonian—meaning be ascribed to them.

Before finishing my task and demonstrating the possibility of adapting structural doctrines to the dynamics of Newton, I consider it indispensable to touch on one question which naturally arises, and which I have heard discussed more than once. If bromine, the atom of which is eighty times heavier than that of hydrogen, takes the place of hydrogen, it would seem that the whole system of dynamic equilibrium must be destroyed.

Without entering into the minute analysis of this question, I think it will be sufficient to examine it by the light of two well-known phenomena, one of which will be found in the department of chemistry, and the other in that of celestial mechanics, and both will serve to demonstrate the existence of that unity in the plan of creation, which is a consequence of the Newtonian doctrines. Experiments demonstrate that when a heavy element is substituted for a light one, in a chemical compound—an atom of magnesium in the oxide of that metal, for example, for mercury, the atom of which is $8\frac{1}{3}$ times heavier—the chief chemical characteristics or properties are generally though not always preserved.

The substitution of silver for hydrogen, than which it is 108 times heavier, does not affect all the properties of the substance, though it does some. Therefore chemical substitutions of this kind, the substitution of light for heavy atoms, need not necessarily entail changes in the original equilibrium; and this point is still further elucidated by the consideration that the periodic law indicates the degree of influence of an increment of weight in the atom as affecting the possible equilibria; and also what degree of increase in the weight of the atoms reproduces some, though not all, the properties of the substance.

This tendency to repetition, these periods, may be likened to those annual or diurnal periods with which we are so familiar on the earth. Days and years follow each other; but, as they do so, many things change; and in like manner chemical evolutions, changes in the masses of the elements, permit of much remaining undisturbed, though many properties undergo alteration. The system is maintained according to the laws of conservation in Nature, but the motions are altered in consequence of the change of parts.

Next, let us take an astronomical case, such for example as the earth and the moon, and let us imagine that the mass of the latter is constantly increasing. The question is, what will then occur? The path of the moon in space is a wave-line similar to that which geometricians have named epicycloidal, or the locus of a point in a circle rolling round another circle. But in consequence of the influence of the moon, it is evident that the path of the earth itself cannot be a geometric ellipse, even supposing the sun to be immovably fixed; it must be an epicycloidal curve, though not very far removed from the true ellipse, that is to say, it will be impressed with but faint undulations. It is only the common centre of gravity of the earth and the moon which describes a true ellipse round the sun. If the moon were to increase, the relative undulations of the earth's path would increase in amplitude, those of the moon would also change, and when the mass of the moon had increased to an equality with that of the earth, the path would consist of epicycloidal curves crossing each other, and having opposite phases. But a similar relation exists between the sun and the earth, because the former is also moving in space. We may apply these views to the world of atoms, and suppose that, in their movements, when heavy ones take the place of those that are lighter, similar changes take place provided that the system or the molecule is preserved throughout the change.

It seems probable that in the heavenly systems, during incalculable astronomical periods, changes have taken place and are still going on similar to those which pass rapidly before our eyes during the chemical reaction of molecules, and the progress of molecular mechanics may—we hope will—in course of time, permit us to explain those changes in the stellar world which have more than once been noticed by astronomers, and which are

[1] "Essai d'une théorie sur les limites des combinaisons organiques," par D. Mendeleeff, 2/11 août 1861, *Bulletin de l'Académie i. d. Sc. de St.-Pétersbourg*, I. v.

now so carefully studied. A coming Newton will discover the laws of these changes. Those laws, when applied to chemistry, may exhibit peculiarities, but these will certainly be mere variations on the grand harmonious theme which reigns in Nature. The discovery of the laws which produce this harmony in chemical evolutions will only be possible, it seems to me, under the banner of Newtonian dynamics which has so long waved over the domains of mechanics, astronomy, and physics. In calling chemists to take their stand under its peaceful and catholic shadow, I imagine that I am aiding in establishing that scientific union which the managers of the Royal Institution wish to effect, who have shown their desire to do so by the flattering invitation which has given me—a Russian—the opportunity of laying before the countrymen of Newton an attempt to apply to chemistry one of his immortal principles.

BABYLONIAN ASTRONOMY.[1]

IV.

THE nightly motion of the stars from east to west appears to have been the only one known to the Babylonian astronomers. The inclination of the equator on the ecliptic brought, however, a few of the austral stars over the horizon at certain times of the year for a short period, and in a few cases, as in that of the star *Sukudu* (Sirius), these stars were used to determine certain periods or festivals. The complicated motion of the planets never was known to them, and the planets were accordingly regarded as evil spirits which disturbed the harmony of Nature. A similar view is taken in the Zend-Avesta. After a cosmical year of 360,000 ordinary years, the series of heavenly and consequently terrestrial events was to begin again.

While the Semitic religion had emerged from tribal monotheism, the Akkadians followed a sect professing Mazdeism—that is, a religion admitting two principles, one good and one bad; but they thought that, as the good gods would not hurt them, it was wise to propitiate the bad ones, and propitiation easily led to worship. That is how the seven planets, the disturbers of heavenly harmony, became their chief deities. For the same reason all disturbing causes, apparent or real, were subjects of their special attention, pestilence, thunder, comets, &c. Eclipses (which they could not predict) were at first also of bad omen, but by a curious reversion they became happy signs.

The ignorance of the Babylonians with regard to astronomy might have been gathered from the statements of classical authors, if they had been examined with an unprejudiced mind. Diodorus Siculus says positively that their notions about astronomy, fixed at an early date, never changed, and that they could not predict the solar eclipses. We also know from a fragment of Berosus, preserved by Vitruvius, that the Babylonians believed the moon to be a globe half incandescent and half dark, the lunar phases and eclipses being produced by its own motion. The errors and contradictions of the Greek and Latin authors, which misled us also, came from the fact that they borrowed their information from the Alexandrian astronomers, who, they thought, derived their science from Babylon. This was true, indeed, but only to a very small extent, as we shall see.

When, after the conquest of Alexander, the Greeks established themselves in Babylon, they imported with them all their scientific knowledge. The Babylonians, who had to learn Greek, soon discovered the accuracy of their new masters in science, and, exactly as did the Chinese astronomers after the settlement of the Jesuits in China, adopted the discoveries of the West.

This is put beyond doubt by the tablets of this period, the Seleucidian, which give tables of the motions of the moon and planets, and mention solar and lunar eclipses without any omens. The Seleucidian astronomers, wishing to use the older observations, made search for old records and tabulated them; these tablets are of the highest interest from the astronomical point of view. The British Museum possesses, for instance, a tablet, written 100 years B.C., giving the list of nineteen lunar cycles of eighteen years—that is, a table combining the Metonic cycle with the *saros*. This *saros*, or cycle of the lunar eclipses, must have been discovered after the settlement of the Greeks; it was called the "king" (*sar* in Babylonian, hence *saros* in Greek) just as the Metonic cycle was called "golden."

The first care of these astronomical innovators was, no doubt, to reform the very defective calendar of former times. They also divided the ecliptic into twelve parts, corresponding to the months, and chose twelve cuneiform signs to represent in their tablets the twelve zodiacal constellations. They then devised the Græco-Babylonian calendar, whence was derived the Jewish one of the time of the Maccabees.

This reform was not made, however, without causing a certain confusion in the star nomenclature, and even in the calendar itself; for, as the older Babylonians used to connect the various parts of the year with the stars or constellations according to their acronic rising, there was a certain hesitation in the choice made by the reformers. Probably this was what caused the parallel use of two calendars, one beginning with Nisan and the other with Tisrit. This hesitation has also left traces in the signs chosen to designate the zodiacal constellations; for instance, the sign representing the month Tisrit in older Babylonian was used to represent the constellation connected with the month Nisan.

It was from this new focus of astronomical science that the Alexandrian astronomers borrowed much of their information. Unfortunately, the old Babylonian superstitions had a most injurious influence on the rising Alexandrian astronomy. Jewish, Syrian, and Babylonian emigrants, fleeing from the Seleucidian tyranny, flocked to Egypt, bringing with them their superstitions and love for allegories. The Alexandrian astronomers accepted with the Babylonian nomenclature all the ideas of influences attributed to planets and stars, and, being able to predict conjunctions, tried to predict events supposed to be due to star influences. Astrology was then born, for astrology, it must be remembered, requires an accurate knowledge of the motions of stars and planets.

In conclusion, it may be said that we owe very little to the old Babylonian astronomers, and if the astronomical work of Berosus had been preserved, it would have given no scientific information, but only long lists of omens drawn from the rising and conjunctions of stars and planets, and also from their colour and other accidental aspects. The loss of such a work is not much to be regretted.

[1] Abstract of the fourth lecture delivered by Mr. G. Bertin at the British Museum. Continued from p. 285.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Annuario dell' Instituto Cartografico Italiano, 1884 (Roma).—Algerian Hints for Tourists: C. E. Flower (Stanford).—Mason Science College, Birmingham; Syllabus of Day Classes, Session 1889–90.—The Visitation of Pallas's Sand-Grouse to Scotland in 1888: Rev. H. R. Macpherson (Porter).—Quarterly Journal of Microscopical Science, July (Churchill).—Madras Journal of Literature and Science for the Session 1888–89 (Madras).—Journal of the Anthropological Institute, August (Trübner).—Journal of the Chemical Society, August (Gurney and Jackson).—Archives Italiennes de Biologie, tome xii., fasc. 1, 2 (Turin, Loescher).

CONTENTS.

THURSDAY, AUGUST 15, 1889.

THE THREE CRUISES OF THE "BLAKE."

The Three Cruises of the "Blake." Two Vols. By Alexander Agassiz. *Bulletin of the Museum of Comparative Zoology at Harvard College*, Vols. XIV. and XV., Cambridge, Mass. (Boston and New York: Houghton, Mifflin, and Co., 1888.)

IN these profusely illustrated volumes there is presented to the general reading public the best and most comprehensive account of recent oceanographical investigations and speculations that has as yet been attempted. These volumes have, moreover, a special value for all who interest themselves in deep-sea researches, from the descriptions that are given of the work carried on with so much ability and industry by Mr. Agassiz and his fellow-countrymen on the eastern and southern sea-boards of the United States and in the West Indian seas. The volumes abound with novel and ingenious views bearing on nearly all the physical and biological phenomena of the ocean; and, whether we agree with the writer or not, his opinions are none the less welcome and suggestive, coming as they do from one who has for many years taken a large part in the practical work connected with the observations which he here undertakes to describe and discuss. It does not seem possible to over-estimate the credit due to the Government and the men who initiated and have carried through this excellent and extensive hydrographical survey of the deeper waters surrounding the eastern shores of North America, nor to value too highly the resulting additions to human knowledge. These positive additions to our knowledge of the ocean will be fully acknowledged and appreciated by all who desire to trace the causes that have led to the development of the surface features of the earth and the existing conditions of life on our globe.

After an attentive reading of the twenty-three chapters into which this publication is divided, it is possible to point out some errors; but slips cannot be avoided in a work dealing with such a wide range of subjects. It is difficult to follow the author in all his speculations, or to agree with him in all the deductions drawn from his excellent and extensive observations, but such agreement was in no way to be expected in these wide fields of research. Almost all the writings and opinions of previous and contemporaneous workers are in some way noticed, and discussed in an appreciative spirit. Mr. Agassiz is in every respect to be congratulated on the completion of this praiseworthy contribution to the growing science of oceanography. So many subjects are presented for discussion and remark that the reviewer is at a loss to know which may with most advantage be touched upon within the limits of a short notice. An attempt may at all events be made to point out the arrangement of the work, and the nature of the varied investigations treated of in the several chapters.

An introduction gives a brief sketch of the cruises of the *Blake*, the extent of the work undertaken, and indicates the localities in which these were conducted. Acknowledgment is duly recorded for the assistance obtained from naturalists in all parts of the world in working out the results of the dredgings. By arrangement the specimens were as far as possible sent to the same specialists as were engaged in describing the *Challenger* collections.

The first chapter deals with the equipment of the ship, which has already been made known through Captain Sigsbee's publication. Mr. Agassiz, from his engineering training in the copper mines of the West, was able to render very valuable assistance in modifying the apparatus for deep-sea work. To him we owe the introduction of wire dredging rope, improvements in the trawl, tow-net, and other apparatus. The use of tangles on rocky ground was very successful, as it was when used in similar places by the *Challenger*. The tow-net for intermediate depths is ingenious, but the experiments with it are in no way sufficient to prove that no living animals are to be found at intermediate depths, as is sometimes asserted. The *Challenger* experiments clearly showed that when tow-nets were dragged for considerable distances at depths of 1000 and 500 fathoms, they always contained animals (Challengeridæ and other Radiolarians and fishes, &c.) never taken in the nets dragged down to 100 fathoms from the surface. While the great development of life in the ocean is in the surface and sub-surface waters, where Algæ abound, and at and near the bottom, where the organic matters are settling on the mud or ooze, yet it appears to me that the *Challenger* has also shown that there is no intermediate lifeless region.

A short chapter gives a fair and impartial historical sketch of deep-sea work, with special reference to the work off the American coast; and a longer chapter gives a very complete account of the origin, development, and present condition of the Florida reefs—the most thorough account of a series of coral reefs to be found in the literature of the subject. Mr. Agassiz successfully explains the phenomena without calling in subsidence, indeed, he found Mr. Darwin's theory quite inapplicable. He rightly places stress on the vigorous growth of the reefs in all situations where they are bathed by currents coming directly from the ocean, and traces this vigorous growth to the abundant pelagic food brought to the reef-forming corals by these oceanic currents. He also dwells on the formation of submarine banks by the dead shells of these pelagic and other marine organisms. Speaking of the Pacific, he says: "It is difficult to account for the great depth of some of the lagoons—40 fathoms—on any other theory than that of subsidence." It appears to me that these depths are only found in very extensive atolls and barrier reefs, and that marine animals, other than the ordinary reef-building species, can build up submerged banks from much greater depths than 40 fathoms. Buchanan, on such a bank in the Atlantic, found *Lophohelia prolifera* growing in large quantities, together with Polyzoa, Crinoids, and other lime-secreting organisms. Besides, in the central parts of the lagoon of completely formed atolls, like Collomandu or Suadiva atolls, the solution of lime by the sea-water probably exceeds in quantity that secreted by organisms, and this process would of itself result in a deepening of the lagoon.

The topography of the Caribbean Sea, Gulf of Mexico, and eastern coasts of North America are illustrated by the admirable hydrographic charts of the Coast Survey. With a thorough knowledge of the various basins, their depths, currents, passages, and contour lines, Mr. Agassiz is well qualified to enter on a discussion of the relations of the American and West Indian fauna and flora, which he does in a most suggestive and instructive chapter. He says :—

"The deep soundings south of Cuba, between that island and Yucatan and Jamaica, do not lend much support to the theory of an Antillean continent as mapped out by Wallace, nor is it probable that this continent had a much greater extension in former times than now, judging from the depths found on both sides of the West Indian Islands. This would tend to prove the want of close connection between the West Indian Islands and the adjoining continent. It leads us to look for the origin of the fauna and flora of those islands to causes similar to those which have acted upon oceanic islands. The proximity of these islands to a great continent has, moreover, intensified the efficiency of these causes."

Since the return of the *Challenger*, the existence of Tertiary continents in the Atlantic, Indian, and Pacific Oceans does not appear to have been seriously advocated. These views have been generally replaced by that which looks upon the continents and ocean basins as holding positions of great permanence on the surface of the earth. Mr. Agassiz adopts this latter view, and illustrates it by special reference to the geological structure of the American continent and its adjoining oceans. In discussing this matter, he expresses the opinion that the "Blake Plateau" was once within the 100-fathom line, and that it has been cut away to its present depth of 500 or 600 fathoms "by the action of the Gulf Stream acting upon the 'Blake Plateau' from a geological time which we can trace with a certain degree of accuracy." This is a most important conclusion, but I cannot think it will be accepted till more evidence of the action of oceanic currents at these depths can be produced. The deposits I have examined from the bed of the Gulf Stream are principally composed of the shells of pelagic Foraminifera, Pteropods, and other organisms living in the present seas of the region, together with much glauconite and many phosphatic concretions. These would lead one to think that the bed of the Gulf Stream was now growing upwards by these accumulations, rather than being washed away.

All the new and valuable observations on the temperatures of the West Indian seas and on the Gulf Stream are presented to the reader with a wealth of illustration in the way of diagrams and maps that leaves little to be desired, and the chapters on these subjects give to the physical geographer many much-needed data.

Mr. Agassiz has long been known to the scientific world for his special researches on the pelagic animals of the eastern North American coasts, conducted chiefly at Newport since 1866. It was therefore to be expected that his observations in this direction would be attractive and important. Nearly all the principal organisms met with in the tow-nets are illustrated in the long chapter devoted to this subject, and the naturalist will here find much new matter and many novel views concerning the origin of this fauna. He says :—

"It seems most natural to look upon the pelagic fauna of to-day and that of former geological periods as made up of embryonic types removed from the influences necessary for their full development, even after a time reproducing themselves as other larval forms are now capable of doing. But to consider that the littoral forms were developed from pelagic types, as has been suggested by Moseley, does not seem to be warranted by the embryological history of marine invertebrates."

The chapters on marine formations, deep-sea deposits and deep-sea fauna contain the latest information and views as to their origin, and the first volume is concluded with a chapter on the physiology of deep-sea life, dealing with the gases in sea-water, the effects of pressure and temperature, phosphorescence, effects of the absence of sunlight, colours of deep-sea animals, source of their food, and other kindred relations.

It is now recognized that the inhabitants of the abysmal regions differ more from the shore species than they do from one another. Perhaps the most striking characteristic of deep-sea species is that they live in a region where there is no plant-life, and that their food consists primarily of the dead remains that fall to the bottom from the surface. All these animals, therefore, either live by eating the mud or ooze of the bottom, or by devouring each other. It appears to me probable that these deep-sea animals are derived from the shore ones, some species descending into these deep regions and establishing a home there at each geological period, while the forms from which they were derived have died out in the shallower waters.

This and all similar questions Mr. Agassiz discusses in his second volume, where he deals specially with the West Indian fauna of the deep sea. He writes :—

"We may safely assume that but little will hereafter be added to our notions of the association of the sponges, polyps, corals, echinoderms, crustacea, and mollusks, comprising the West Indian deep-sea fauna, and making it in certain groups by far the richest in the world. The number of new forms from the West Indian region constitutes such a vast addition to our knowledge of the principal classes of invertebrates of that fauna as to revolutionize our ideas of geographical as well as of bathymetrical distribution. No other region of the ocean has yielded so abundant a harvest."

I should think that in proportion to the number of dredgings, the regions in the Southern Ocean investigated by the *Challenger*, or off the north of Scotland worked over by the *Porcupine* and *Triton*, might be held to be quite as rich as those of the West Indian Islands. It is to be hoped that this will be shown before long by an expedition thoroughly equipped for examining the deep waters around Britain.

In a series of nine chapters in his second volume Mr. Agassiz attempts for the first time to give a general account of the deep-sea fauna in the areas explored by the *Blake*, commencing with the fishes, and ending with the Protozoa. In this he has been remarkably successful by the help of numerous illustrations. For details the reader must be referred to the volumes themselves, which will be widely consulted, and will well repay all who give them attentive study.

JOHN MURRAY.

KANT'S "KRITIK."

Kant's Critical Philosophy for English Readers. By J. P. Mahaffy and J. H. Bernard. (London: Macmillan and Co., 1889.)

THE abundance of Kantian literature within recent years shows no signs of abating. In Germany itself there is quite a school of students who have taken for their motto "We must go back to Kant," while in England the able commentaries of Prof. Caird and Prof. Watson have been succeeded by the studies of Dr. Hutchinson Stirling, Prof. Max Müller, and Dr. Mahaffy. The old translation of Mr. Meiklejohn still holds its own, though Mr. Belfort Bax and others have tried their hands on Kant, and made many improvements in detail. It is clear that the famous "Kritik of Pure Reason" is still regarded as a necessary element in all philosophic education, and as likely to continue longer in fashion than the more brilliant but less solid speculations of Schopenhauer and Von Hartmann, as well as of the more legitimate descendants of the Königsberg school.

There are certain well-known difficulties in Kant's philosophy to which the reader naturally turns when he has in his hands a new commentary on the "Kritik." Is any fresh light thrown on the schematism of the categories, or on the number and derivation of the categories themselves? Are we enabled to understand better the precise value of the principle of causation, or the principle of the permanence of substance? Above all, shall we be satisfied to accept the second and first editions of the "Kritik" as alike containing the true gospel of Kantianism, or are we to be left to suppose that there is a serious divergence between the earlier and later edition, especially in reference to idealism and the refutation of Berkeley? These are a few salient points out of many others on which we look for guidance to some fresh commentator. In the case of one of these, we have for some time been aware of Dr. Mahaffy's opinion. We know that in his early version of Kuno Fischer's "Commentary" he was dissatisfied with that philosopher's treatment of Kant on the subject of idealism. Dr. Mahaffy returns to the charge in the present edition (in which he has the collaboration of Mr. Bernard), perhaps in some measure stirred to resume the controversy by the discovery that Kuno Fischer in his recent "Critique of Kant" (1882) had not found reason to alter his original views. As the point is an important one, and as Dr. Mahaffy would probably himself select its treatment as the most characteristic contribution which his new edition has to offer to the better comprehension of Kant, we shall attempt as briefly as possible to lay the question at issue before our readers.

It was Schopenhauer who decisively stigmatized the second edition of the "Kritik" as inferior to its predecessor. Kant, he declared, had become alarmed at the idealistic conclusions which had been drawn from his principles, and proceeded to mutilate the earlier version of his doctrines by suppression of some passages, and alteration of others. There was one paragraph especially, inserted into the deduction of the categories, which stated in the most explicit terms that the "matter" of our intuitions is derived from a source independent of the understanding; and there was the comparatively long excursus introduced under the heading of a "Refutation of Idealism," which seemed expressly intended to reassure those who thought that Kant had taken up the position of Berkeley. Hence the conclusion was drawn that Kant, "in the weakness of old age," had compromised with the Realists, and that the second edition, in consequence, was by no means so clear and consistent an exposition of Kant's own opinions as the one it was intended to supersede. It is this opinion (which others besides Schopenhauer have entertained) which Dr. Mahaffy sets himself to oppose. He draws attention, in the first place, to Kant's own words in his preface, which contain the most unqualified statement of the practical identity of the two editions. "In the positions themselves," says Kant, "and in the grounds of proof, as well as in the form and completeness of the plan, I have found nothing to alter;" and again, "my present exposition, in substance, as regards the propositions, and even in their method of proof *changes absolutely nothing*, while it varies from the former here and there in the method of the exposition in such a manner as could not be managed by interpolation." These words are certainly explicit enough, and if we are to venture to disregard them, as Kuno Fischer has done, it can only be because on such a question the opinion of the author himself is perhaps not wholly trustworthy, or at all events ought not to be allowed to overbalance the evidence derived from a comparison of the editions. Such a comparison Dr. Mahaffy himself undertakes, and is thereby led to the conclusion that Kant's own judgment was right, and that of his critics was wrong. On the whole, it may be conceded that Dr. Mahaffy makes out his case, but even he would probably allow that the general tendency of the second edition is to accentuate Kant's avoidance of the idealistic position, and to effect, by a not too successful criticism of Berkeley, a reconciliation with the realistic position. Such a tendency is undoubtedly absent in the first edition. Indeed, Dr. Mahaffy admits, in a note on p. 23, that "it may be that Kant was somewhat frightened at the charge of Berkeleianism"; and the history of the controversy on this point given by Dr. Stirling in the eighth volume of *Mind* entirely confirms the opinion that in some fashion the effect produced by the first edition was one which Kant set himself to alter.

One of the important passages is, of course, the "Refutation of Idealism," which, although it was not wholly new, but had already been outlined in the first edition among the "paralogisms," still deserved the attention which the German critics gave to it because of the new position and importance which it assumed in the revised version. Is it the case, as the Idealists assumed, that the intimations of the inner sense (internal experience) are more trustworthy than the intimations of the outer sense (external experience)? May we rightly argue from sensations to the percipient who is the subject of the sensations, although we are debarred from arguing from sensations to the "matter" or external object to which the sensations are referred as their cause? According to the "Refutation of Idealism," Berkeley is clearly wrong: both inner sense and outer sense have precisely the same validity, inasmuch as both yield us "phenomena" of the same value: while it is also suggested that were it not for the *permanent* object of sensation, no sense of change, no sequence in the intimations of the inner sense, would be possible at all. Dr. Mahaffy devotes a chapter (chap. xiv.) to the discussion of this question, and we venture to think that there is no part of his work which more deserves an attentive perusal. We would especially point to the passages in which he discusses the precise meaning of Kant's principle of permanence (pp. 212 *et seq.*). Berkeley's polemic against matter was a disproof of the supposed substratum of qualities. But, according to Kant, Berkeley confused matter as a substratum of qualities with matter as a thing *per se*. No doubt we can never prove the existence of matter as a thing *per se*. On the other hand, the notion of a substratum is necessary in our knowledge in order to account for that permanence without which there would be for us no real world at all. This permanent substratum is itself *phenomenal*, because we can form no notion of permanence *except in space*, and space is a form of sensible intuition. Hence Kant would be the last to sanction any speculations on the permanence of unknown things *per se*: he is no materialist in the vulgar sense of the word; but he is, to the extent above explained, a problematical realist, in so far as he accepts the necessary principle of a permanent phenomenal substratum. If we further ask, Whence do we obtain this notion of permanence? Kant answers that we derive it "from the fact that all our experience is comprised in one time, which time cannot be perceived in itself, but only when occupied by some perception. Hence we infer the permanence of the matter of experience, of phenomenal substance, the changing states of which correspond to the various portions of changing time comprised in the one great complex of time. Thus we represent to ourselves the permanent, even though we have no permanent representation; and as an empirical criterion of this permanence in time, we use impenetrability, or modes of resistance in space" (p. 213).

Kant was, however, not content with merely indicating the equal authority of external experience as compared with internal experience. He advances to a still bolder position. While both external and internal experience, although they can give us no information concerning, objects *per se*, are equally immediate and equally certain Kant thinks that it can also be proved that in some respects external experience is the more important of the two. For internal experience is, after all, only possible if we presuppose external experience. Internal experience is subject to the form of time; it is made up of changing modes of consciousness. But change can only be understood if we already have the notion of permanence ("only the permanent can change," says Kant), and the notion of permanence is to be found in that permanent substratum which underlies all our external experience. Hence it is so little true that internal experience is more certain than external that the reverse is almost the case. Without external experience there would be for us no possibility of internal. Where Kant's critics have generally gone wrong is in assuming that where Kant speaks of a permanent substratum he means a thing *per se*. But this is not the case. What he means is a phenomenal substratum, the non-recognition of which is the fatal error of Berkeley.

We have spent so much time and space over this point that we have left ourselves but little opportunity to speak of others. But we do not think we are wrong in assuming it as the point of capital importance in Dr. Mahaffy's new edition, especially as it is at once the most original and the most effective part of his polemic against Kuno Fischer and other German critics. But there are many other features which deserve attention, although we can do no more than refer to them. We would especially direct the reader to the following. Let him observe Dr. Mahaffy's clear explanations of Kant's passage from the ordinary table of logical judgment to that of the categories (pp. 80 *et seq.*), his treatment of the categories themselves (pp. 88 *et seq.*), as well as his vindication of Kant against Mansel, Fichte, and other critics of the categories (pp. 100 *et seq.*). Chapter vii., on the deduction of the categories, is an important one, especially as it compares the "Prolegomena" with the "Kritik." If Dr. Mahaffy has not been able to bring into clearer light the difficult and unsatisfactory treatment which Kant has given to his principle of causality (pp. 180 *et seq.*), he at all events has effectively criticized Schopenhauer's carpings at the Kantian categories and schemata (pp. 151 *et seq.*). Mr. Bernard's contributions to the commentary begin with chapter xvii., and deal with Kant's "Dialectic of the Pure Reason," but we believe that for most students the chief interest of this new edition will be found to be concentrated in the commentary on the "Analytic." It should be added that the second volume is a translation of Kant's "Prolegomena," and contains also, in the appendix, the suppressed passages of the first edition of the "Kritik." The whole edition forms a striking and valuable version of the logical views of Kant, and we can imagine no more helpful text-book both for older and younger students of Kant's immortal "Kritik." W. L. COURTNEY.

OUR BOOK SHELF.

Monograph of the Marine and Fresh-water Ostracoda of the North Atlantic and of North-Western Europe. By Dr. G. S. Brady and Rev. A. M. Norman. (London: Williams and Norgate, 1889.)

ABOUT twenty-one years ago Dr. G. S. Brady published, in the Transactions of the Linnean Society of London, a monograph of recent British Ostracoda. The present monograph is to some extent a supplement to the former one, but as it embraces the description of the forms belonging to a greatly extended area, it may be regarded in the light of a new work, in the publication of which the authors have been ably assisted by the contributions of most of those zoologists interested in this group of Crustacea. The present memoir deals only with the section of the Podocopa. The geographical area embraces the Arctic Seas, the North Atlantic Ocean, and North-Western Europe. The North Atlantic area is fixed at 35° N., thus excluding the tropical species of the West Indies and the Gulf of Mexico; the Mediterranean is not included, as the doing so would have too greatly extended the limits of the work; and the North-Western European area embraces Austria, Germany, France, Belgium, Holland, Denmark, Scandinavia, and the British Islands. The distribution of the living species, as far as known, is recorded. One hundred and eighty-eight species inhabiting salt water are recorded, and sixty-one fresh-water forms, and yet it is certain that the record is still very incomplete. While the marine species of Norway and Sweden have been in part studied, little has been done with respect to the marine species of Denmark and Germany. The knowledge of the Dutch marine forms has been derived from some dredgings in the Rivers Maas and Scheldt. Those of the Belgian and French coasts are also but little known, and the same may be said of the truly Arctic species, while nothing is known of the forms inhabiting the coasts of the United States or Canada.

The fresh-water Ostracods of Norway and Sweden have been more or less investigated by G. O. Sars and Lilljeborg; in Denmark by no one since the time of O. F. Müller (1785); in Holland not at all; in Belgium only by Plateau: in Germany by Koch, W. Müller, and Zaddach, whose type species were very generously intrusted to Brady and Norman by Prof. Seeliger, of Königsberg. In France, the species have only quite recently been investigated by Moniez. Those of Great Britain are the only ones at all extensively worked out.

This monograph, which consists of 200 quarto pages, is illustrated with fifteen plates, and is published as Part II. of the fourth volume of the Transactions of the Royal Dublin Society.

The Harpur Euclid. Books I.—IV. By E. M. Langley and W. S. Phillips. (London: Rivington, 1889.)

THIS is an edition of the "Elements" "revised in accordance with the Reports of the Cambridge Board of Mathematical Studies, and the Oxford Board of the Faculty of Natural Science." The favourable impression made upon us by the two previous instalments of Books I. and II. is thoroughly confirmed by the additional matter now before us. We are not going to say that it is the best edition we have seen, for lately we have had under our notice two or three excellent works on much the same lines, but it is certainly not inferior to any of these, whilst for the arrangement of the text, the variety of type, and boldness and *correctness* of the figures, it is admirably adapted for school purposes. The editors, following on the lines of Mackay's interesting edition, have supplied ample store of illustration and historical matter, which will render the study of "Euclid" interesting to the intelligent boy. Not content with embracing within their net an account of Simson's line and the nine-point circle, Mr. Langley, in an article on the principal circles of a triangle, has given an excellent though brief description of the properties of symmedian lines and of the Brocard, cosine, and other modern circles, thus bringing the teaching of these circles within the range of the school curriculum. The exercises now reach the respectable total of 677, and to many of them useful hints for their solution are appended. We await the completion of the authors' task with interest, for a good work on elementary solid geometry is not altogether superseded by Nixon's admirable manual.

An Elementary Treatise on Mechanics. Part I. Statics. By Rev. J. Warren. (London: Longmans, Green, and Co., 1889.)

THIS is an elementary treatise intended for the use of schools and University students. The arrangement and methods of reasoning are best adapted for students who have made some acquaintance with trigonometry. At the same time a considerable portion of the book may be read by those students not possessing such mathematical knowledge. Each chapter contains a good selection of examples, some of which are worked out. This feature, together with the fact that the various theorems and results are very clearly established, will help to render the book a useful one. An experimental proof only is given of the parallelogram of forces, other proofs of which will be found in the second part of the work, which is devoted to dynamics. G. A. B.

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 Earlier Eruptions of Krakatão.

AT the time when a Committee of the Royal Society entrusted me with the preparation of a sketch of the geological facts bearing upon the great volcanic eruption of Krakatão in 1883, I was quite unaware that any reliable records concerning the early history of the East Indian Archipelago were in existence. I stated, therefore, that authentic history commenced only about three centuries ago, when the district began to be visited by the Dutch and Portuguese navigators; and that the earliest eruption of which we have any detailed account was that of 1680, described by Vogel and Hesse.[1]

At the same time, however, I pointed out that the study of the geological structure of the district—so well described by Mr. Verbeek and by MM. Bréon and Korthals—especially when that structure was considered in the light afforded by other volcanic areas that have been investigated by vulcanologists, led to very definite conclusions as to what must have been the early history of the great volcano.

It was shown that Krakatão is situated on a fissure traversing the Sunda Strait and running at right angles to the great band of volcanic activity which traverses the islands of Java and Sumatra; and it was inferred that at a very early period a volcano of great height and bulk was built up at the point marking the intersection of the two lines of fissure; it was then stated that—

"At some unknown period this volcano became the scene of an eruption, or series of eruptions, which, judging from the effects they have produced, must have been on even a far grander scale than that which four years ago attracted so much interest. By these outbursts the whole central mass of the volcano seems to have been blown away, and only an irregular crater-ring left behind. The great crater thus formed must have had a diameter of three or four miles, and its highest portions could have risen but a few hundreds of feet above the present level of the sea."

After pointing out that this crater-ring became to a great extent filled up by a succession of smaller eruptions, I proceeded to say:—

"Whether the tract now constituting the Strait of Sunda was then dry land uniting the islands of Java and Sumatra, we have no means of determining; but I may point out that there are some grounds for believing that the formation of the depression occupied by the straits was subsequent to the evisceration of the volcano."

After stating what these grounds are, I added:—

"It seems not improbable that the depression between the islands of Java and Sumatra may have resulted from subsidences accompanying or following the ejections taking place at the great central volcanic focus of Krakatão" (*loc. cit.*, pp. 7–8).

I am greatly indebted to Mr. C. Baumgarten, of Batavia, who, through Dr. R. Rost, the Librarian to the India Office, has called my attention to some ancient records that seem to confirm, in a singularly striking manner, these conclusions arrived at by scientific reasoning.

Mr. Baumgarten writes as follows:—

"In a Javanese book called 'Pustaka Raja,' the 'Book of Kings,' containing the chronicles of the island, kept secret during centuries in the Royal Archives, and only recently made public, we find the following interesting and curious account of an eruption of the mountain Kapi:—

"'In the year 338 Saka [*i.e.* A.D. 416], a thundering noise was heard from the mountain Batuwara,[2] which was answered by a similar noise coming from the mountain Kapi, lying westward of the modern Bantam. A great glaring fire, which reached to the sky, came out of the last-named mountain; the whole world was greatly shaken, and violent thundering, accompanied by heavy rains and storms, took place; but not only did not this heavy rain extinguish the eruption of fire of the mountain Kapi, but it augmented the fire; the noise was fearful, at last the mountain Kapi with a tremendous roar burst into pieces and sunk into the deepest of the earth. The water of the sea rose and inundated the land. The country to the east of the mountain Batuwara, to the mountain Kamula,[3] and westward to the mountain Raja Basa,[4] was inundated by the sea; the inhabitants of the northern part of the Sunda country to the mountain Raja Basa were drowned and swept away with all their property.

"'After the water subsided the mountain Kapi and the surrounding land became sea and the Island of Java[5] divided into two parts.

[1] "The Eruption of Krakatão and Subsequent Phenomena," Report of the Krakatão Committee of the Royal Society (1888).

[2] "Now called Pulosari, one of the extinct volcanoes in Bantam, and the nearest to the Straits of Sunda."

[3] "Now called the 'Gedé' mountain."

[4] "The most southern volcano of Sumatra, and situate in the 'Lampung' country."

[5] "The Sanskrit *Yawa-dwipa.*"

"'The city of Samaskuta, which was situate in the interior of Sumatra, became sea, the water of which was very clear, and which was afterwards called the lake Sinkara.[1] This is the origin of the separation of Sumatra and Java.'"[2]

Whether we are justified in accepting this date (A.D. 416) as that at which the very grand eruption of Krakatão, and the accompanying subsidence which led to the separation of Java and Sumatra, actually took place, I am not prepared to say. It may be that, as in many similar cases, the floating traditions of a grand catastrophe attached themselves to a subsequent event of a similar character. It is certainly very interesting to learn, however, that in the fifth century very grand volcanic outbursts were taking place in the district in question; and that a belief existed in the former connection of the islands of Java and Sumatra. Nor is it unimportant to discover that tradition is in complete harmony with scientific reasoning in assigning the separation of the two islands to actions occurring concurrently with great volcanic outbursts.

In concluding this note, I must express my great obligations to Mr. Baumgarten and Dr. Rost for bringing these important records under my notice. JOHN W. JUDD.

On some Effects of Lightning.

PROF. MCMILLAN'S interesting letter in NATURE of July 25 (p. 295) contains some minute details of the effects of a lightning-stroke on a house near Calcutta, on June 8 last. I agree with the writer that such cases are of value to electrical science, especially when reported by a competent observer. In Prof. McMillan's excellent letter there is one word to which I object, and that is "vagaries," as applied to electricity at high potential. When lightning enters a house, it is as much subject to law as when it flashes from the cloud to the earth, and does not behave with the whim, caprice, or freak implied by the word "vagary." In the absence of continuous conductors, the electrical discharge drags into its path light, conducting substances, which assist its progress, and by means of which it can strike through considerable distances and in various directions, as in the case before us. As to the effect of the discharge on the air of the house, Mr. McMillan appears to have made a real advance towards the solution of a difficult problem—namely, What is the origin of the powerful odour produced by a lightning-discharge within an inclosed space, such as a room or a ship? In most cases, the odour is compared to that of burning sulphur—"the ship seemed to be nothing but sulphur," was entered in the log of the *Montague*, after having been struck by lightning. Now as far back as 1785, Cavendish's famous experiment proved that electrical discharges in a confined mass of air lead to the formation of nitric acid, and Liebig found that acid in seventeen samples of rain-water collected during thunder-storms. Nevertheless, with these facts before him, Snow Harris wrote: "From whence this odour arises is still an interesting problem in physics," and he declines to discuss "those chemical views which some able philosophers have entertained of the nature of the odour emitted." Arago also states that the odour is generally compared to that of burning sulphur; but he adds: "others compare it to phosphorus, others to nitrous gas"; and significantly remarks: "L'odeur de gaz nitreux serait le plus facile à expliquer." Now, Prof. McMillan has shown that nitrogen teroxide, more or less diluted with air, was sufficient in the case so ably reported by him, to account for the colour and odour of the atmosphere produced within the house by the electric discharge. "The whole house seemed to be filled with an orange-coloured gas, mixed with clouds of dust affecting the breathing like fumes of burning sulphur," is the description given by the occupier of the house.

Another point of interest in this valuable communication is the introduction of ball-lightning. Arago is sceptical as to the existence of ball-lightning (*éclairs en boule*), or that which moves through the air at a comparatively slow rate, appearing like a luminous ball or globe of fire. Faraday is also equally sceptical. But the well-attested cases of what we name ball-lightning, and the Germans *Kugelblitz*, are so numerous that they can no longer be termed, in Arago's language, "a stumbling-block (*pierre d'achoppement*) for meteorologists." Snow Harris properly describes these luminous balls as a kind of brush or glow discharge. In the well-known case of the *Montague*, the luminous ball was seen rolling on the surface of the water towards the ship from to windward; evidently a brush discharge, or St. Elmo's fire, produced by some of the polarized atmospheric particles, yielding up their electricity to the surface of the water. On nearing the ship, the point of discharge became transferred to the head of the mast, and, the striking distance being thus diminished, the whole system returned to its normal state—that is to say, a disruptive discharge ensued between the sea and the clouds, producing the usual phenomena of thunder and lightning, described by the observers as "the rising of the ball through the mast of the ship." In Prof. McMillan's case I do not understand his remark that "no second ball was seen to enter from the opposite side to meet the first, and so produce the apparent explosion." Surely a second ball was not necessary to produce the effect described—namely, "an intensely brilliant ball of yellow fire, about 6 or 7 inches in diameter, which passed from one end of the room to the other at a pace just sufficiently slow to allow it to be readily followed by the eye: it appeared to be momentarily checked, then burst with a deafening report, which shook the whole house." In other words, it passed from a brush into a disruptive discharge.

Lastly, we have another remarkable confirmation of the fact that a lightning-conductor does not afford protection to surrounding objects. According to the French theory, a lightning-rod affords protection over a circle equal to twice its radius. But there are numerous cases to prove that no such radius of protection exists. The *Endymion* frigate, at Calcutta, in March 1842, was furnished with a chain conductor on the mainmast, but the lightning struck the foremast, shivered the topgallant and topmast, and damaged the lower mast. The mast struck was not above 50 feet from the mainmast. A somewhat similar accident happened to the *Etna* in Corfu, in January 1830. So also in the case that excited so much discussion at the time, the Board-house at Purfleet was struck on May 12, 1777, at a point about 40 feet from the conductor. A similar case occurred at the Poor-house at Heckingham in June 1781. So also in the recent Calcutta case, there was a conductor at one end of the building, projecting 8 or 9 feet above the roof-level. But the lightning entered the house by an iron-covered hatchway, 70 feet from the conductor, and near to a shell factory, which bristled with conductors.

Prof. McMillan properly attaches great value to such cases as the one he reports, leading as they do to the conditions which should govern the protection of buildings. In the course of a long experience, I have noticed that the profession which should be the best instructed on the subject, is—I hope I may say was—the worst. When the new buildings for the Cholmeley School at Highgate were being erected, the head master consulted me as to the erection of a lightning conductor, and asked me to see the architect. That gentleman called on me and said, "We never put up these things; we don't approve of them. I never erected one in my life, and don't know how." I once visited a church in Rutlandshire, that had been restored by Sir Gilbert Scott. The rector took me to one of the gable ends, and said, "You see, we have a lightning conductor, properly insulated by means of glass rings." I replied that on visiting the granite lighthouse at the end of the Plymouth breakwater, I noticed that Faraday, in fixing a lightning conductor, had caused a spiral groove to be cut inside the shaft from top to bottom, for the insertion of a massive copper band, so as to make the conductor an integral part of the building. Snow Harris's method of protecting a ship applies also to a building. At whatever part of the ship or building the lightning may strike, it ought to find an easy metallic path to the sea, or to the earth. The late Prof. Clerk Maxwell, writing to me as to the best method of securing a building, proposed to inclose it with a network of good conducting material, such as a copper wire, No. 4 British wire gauge, to be carried round the foundation of the house, up each of the corners and gables, and along the ridges. Further details would occupy too much space on the present occasion.

Highgate, N., August 1. C. TOMLINSON.

SOME weeks ago, two trees were struck by lightning near St. Albans, in Hertfordshire, the effects of which are most unusual. The two trees stood near each other in a wood called Symonds Hyde Wood. Assuming that the lightning struck downwards, it is easy to see in one case where the damage began—namely, at a place where a branch had by some means been broken off formerly, leaving a ragged break, into which no doubt water had soaked. Thence for some feet downward the effect was

[1] "The well-known Lake of the 'Menang-Kebo' country."
[2] See the "Krakatão Eruption and the Javanese Chronicles" in *Trübner's Record* for August 1889 (third series, vol. i. pt. 3).

apparently merely to split the bark in the usual way. But, at a height of about 20 feet from the ground (as I judged), something in the nature of an explosion must have taken place. Not only is the bark stripped absolutely clean off in large sheets from the level of the ground up to a height of about 30 feet, some of the sheets having been shot to a considerable distance, but where the explosion seems to have occurred, and for a considerable height above and below, the solid timber is burst open and broken into shivers, and the tree, which was a very fine one, is broken short across at the point where the greatest amount of splintering has taken place. Here, too, a considerable branch seems to have been wrenched off by the explosion.

The other tree is at a distance of perhaps 30 yards, and was, if anything, a still finer one. The appearances here are precisely similar, except that the lightning, which I imagine was conducted along the wet surface of the twigs and smaller branches at the top of the tree down to the junctions of the main branches with each other and the stem, here appears to have struck into the wood, tearing the bark up into rough filaments, which still remain attached to the surrounding bark. Most of this tearing occurs at the angles where the main branches join; but I noticed two places, each about the size of a five-shilling piece, each of which was at some distance above an angle. One such "bruise" appears also in the first-mentioned tree, some distance above the broken bough where the main body of the electricity appears to have entered. The "explosion" in the second tree was at a less height than that in the other.

It has been suggested that a good deal of the splintering may have been caused by the trees, weakened by the stroke, having been broken short off by the storm of wind which presumably raged at the time. I do not think this a probable explanation, for the following reasons. The trees are well within a considerable wood, where the effect of such a gale would not be fully felt, while the two tops are now lying almost at right angles to one another; not parallel as one would expect if the same gale of wind had overthrown them. It appears most probable that a violent explosion occurred, not exactly in the middle of the stem, but rather to the side remote from that to which the tops have fallen. I think it will be found that all the appearances agree with this explanation.

The destructive nature of the strokes cannot be adequately described by words: long splinters, of wedge-shaped section, are sticking up everywhere at the place of fracture, while many feet below it a pen-knife can be inserted easily in numbers of crevices which run up and into the stem along the radial lines which are always formed in the growth of oak timber, and which have here been split open.

Some black stains on the soil at the foot of the trees are pointed out as the effect of the "fire." It will be seen, however, that these are caused by the tannin in the oak sap staining the iron-impregnated clay soil.

I have seen numbers of lightning-struck trees, but have never seen anything to compare with these, and I much hope that some one, with more knowledge of lightning and its effects than I have, will take the train to St. Albans, with a photographic apparatus, and see and judge for himself, and give us some explanation. If he will write to my father (Rev. Dr. Griffith, Sandridge Vicarage, St. Albans, Herts), with a couple of days' notice or so, he will be happy to do all in his power to help, and will no doubt drive him to the spot.

Readers of NATURE may possibly remember a former letter of mine, written, if I recollect aright, in the autumn of 1879, describing a sparrow and her nest, flung out of a crevice in a chimney struck by lightning—the bird almost entirely plucked. The bird I placed in spirits, and deposited in the Cavendish Museum at Cambridge. The barking of these trees reminded me of the plucking of that bird.

A. F. GRIFFITH.

15 Buckingham Place, Brighton, August 8.

A Brilliant Rainbow.

FROM the veranda of this Club, several of the members, including myself, have, within five minutes of the time of writing this (6.30 p.m.), witnessed a phenomenon the parallel to which we have never seen before—a most brilliant rainbow, the usual parallel reflection, and another rainbow *or* reflection quite as brilliant as the ordinary and usual reflection, at an angle which I sketched at the moment, but which, as I have no compasses, I cannot draw semicircular. The tide is out, and nothing but little puddles of sea are left.

E. BURTON DURHAM.

Alexandra Yacht Club, Southend-on-Sea, August 11.

THE 1851 COMMISSIONERS' ESTATE AT KENSINGTON.

A NEW light has been thrown upon the proposals of the Commissioners of 1851, to make grants for provincial Museums, and to found Scholarships of science and art, which were discussed in NATURE of July 18 (p. 265). As was then explained, the carrying out of these proposals would necessitate the sale of a considerable portion of the Commissioners' estate at Kensington Gore. We also showed that public protests had been raised during the last three months against any such sale; further, that State aid in co-operation with local effort has provided the country with a system of science and art Scholarships and grants for provincial institutions, and that the Commissioners are not in a position also to launch and administer a corresponding system of grants and Scholarships themselves, for the benefit of the country. But as the Commissioners have published a notification of their intention to proceed with their scheme, it is perhaps but natural that, when it is attacked, they should defend their position as ably as may be. The attack which has been made upon their scheme is twofold in character, but it aims chiefly at the preservation of the inner gardens of the estate from the degradation of being sold for and used as a common site for private houses, to the unavoidable detriment of the institutions upon the estate.

As regards the scheme for grants and Scholarships, Mr. Samuelson, M.P., gave notice of a question in the House of Commons to Sir Lyon Playfair, the gist of it being whether, in formulating their scheme, the Commissioners had examined, and taken account of, the scheme (identical in direction) which has been for years and is in operation under the Science and Art Department. Sir Lyon Playfair transferred the answering of this question to the Home Secretary, who stated accordingly that the Commissioners' scheme was being prepared, and would be printed in due course and laid before the House of Commons. Under these circumstances, we may postpone further remarks upon the Commissioners' grants and Scholarships scheme until it is printed in a complete form and submitted as promised.

In the meantime, however, we must take notice of another incident connected with the Commissioners and their proposals. On July 19, Mr. Bartley, M.P., gave notice of a question to be asked of Sir Lyon Playfair on July 22. The question was, whether Sir Lyon would, as a Commissioner of 1851, state the names of the different persons, public bodies, and institutions which had sent protests to the Commissioners for the Exhibition of 1851, against the proposed sale of part of the inner gardens of their estate at Kensington Gore for private buildings. Sir Lyon Playfair, however, was not in his place when the question should have come on on the 22nd. It was postponed to the 23rd; and when the printed notice paper for that day appeared, it was found that an arrangement had been made for the question to be answered, not by Sir Lyon Playfair, but by his brother Commissioner, the Home Secretary. The question was therefore asked of that Minister, and, before the answer to it could be given, Sir Lyon Playfair got up and asked whether the right hon. gentleman was aware that a deputation of the Mayors of nearly all the largest towns in England and Wales, representing a population of more than 3,000,000, had waited on the Commissioners to urge that the property in South Kensington should be sold and realized, in order to be applied to provincial Museums. Mr. Matthews replied to both the questions in one answer.

There had, he said, been protests from public bodies and towns against the sale of the estate, and it was also the case, as indicated in the question of Sir Lyon Playfair, that a deputation had waited on the Commissioners and urged the sale. The impression thus conveyed was, that the Commissioners had quite recently been between two fires, and had given way under the hottest. This would be a poor enough plight for a body of public men, who, up to within the last three or four years, had been consistent and strong enough to adhere to the main lines of a policy traced out for them in 1852, when they were charged with a public trust. But it is worse than a poor plight when considered, as it has to be, in conjunction with matured opinions and resolutions published by that same body of men in 1878.

The deputation to which Sir Lyon Playfair directed attention waited on the Commissioners, not, as was imagined, quite recently, but as long ago as 1877. The deputation was received at Marlborough House on June 20, 1877, and was headed by Mr. Chamberlain. The Prince of Wales made a very brief reply to it; and Lord Granville delivered a full exposition of the Commissioners' reasons for disagreeing with the views of the deputation. The deputation "proposed, as the best method of dealing with the Commissioners' trust: (1) the realization of the estate to as great an extent as possible; and (2) the application of the realized funds, in grants to provincial Museums for buildings, and for the purchase of suitable objects for exhibition therein." Amongst other statesmanlike views of their responsibilities towards their trust and to the public at large, Lord Granville, on behalf of the Commissioners, pointed to the importance, in the founding of provincial Museums, of voluntary subscriptions, and to the "danger of stopping the flow of them if you [the deputation] get a great central body supplying everything. There is the consideration how far even a large sum would go." The possibility of realizing a portion of the estate was mentioned; but it should be clearly stated that that portion of the estate was a site lying to the *south* of the present Imperial Institute. No portion of the inner gardens, upon which the Albert Hall abuts, was to be put up for sale.

It will be useful to now give extracts from the Sixth Report of the Commissioners published in 1878, shortly after the deputation above referred to had waited on them.

"The claim of the provincial towns to share in the application of our funds was supported by two considerations. In the first place, it was said that the support which enabled the Exhibition of 1851 to be held was obtained, to a large extent, from our great manufacturing centres. As a fact, the metropolis subscribed £35,108 16*s.* 11*d.*, and the provinces £34,057 12*s.* 8*d.* The second consideration urged was the difficulty which is felt in provincial towns in raising, by means of rates, amounts adequate to meet the expenses of building and maintaining scientific museums and galleries of art.

"That we are not insensible to the claims of the provinces to a share of the benefits to be derived from the resources at our command will be seen from the resolutions at which we have arrived, but as to the form in which such benefit should accrue we hold different views from those expressed by the deputation. In the first place, we consider that the proposal to capitalize the whole of our property cannot be entertained, because, apart from all other reasons, it is sufficient for our present purpose to observe that it would clearly be at variance with the appropriation of the land originally contemplated, and a reversal of the whole past policy of our body.[1]

"The object with which, under the guidance of the Prince Consort, we purchased the estate was to provide a remedy for the want so often felt in this country of an extensive site for the development of great institutions for the promotion of industrial art and science amongst the manufacturing population. The South Kensington Museum and the Museum of Natural History are two great monuments of the prudence of the course adopted, and, so long as the wants of technical education are so inefficiently provided for in this country as they are at present, we think that we ought to keep in our hands the means of meeting the possible requirements of institutions for that purpose. . . .

"The suggestion that the resources at our command might be applied to the promotion of local Museums of Science and Art, by grants in aid of buildings or collections of suitable objects, had received our full consideration before the deputation of provincial municipal representatives, already referred to, pressed this course upon us. The establishment of local Museums is an object which has long commended itself to us. In the original scheme, drawn up in the year 1868, for the series of annual International Exhibitions, it was proposed that 'a sum of money might be annually devoted to make purchases of remarkable objects, which might be sent to local Museums throughout the country.' If this scheme had proved permanently successful, we might have been able to supply, by degrees, each of the principal centres of industry with collections of objects illustrating the manufactures in which they are chiefly interested. But, in the present condition of our trust, we see several objections to the promotion of local institutions as a method of applying our resources. Firstly, the amount of the funds at our disposal is very limited, as compared with the numerous demands which might legitimately be made upon us in case we announced our readiness to make grants in favour of local institutions. Secondly, we fear the risk that the knowledge that a central body was ready with funds to assist local objects would have the effect of decreasing rather than stimulating private local subscriptions, and of producing a lukewarmness in local efforts which would far more than counterbalance the moderate amount of assistance which a share of our funds would provide. Thirdly, and chiefly, it is evident that such grants, while exhausting our funds, would result in mere temporary help to science and art."

The above extracts relate to the deputation to which Sir Lyon Playfair has drawn attention, and upon whose views, very distinctly controverted by the Commissioners, he seems to rely for justification in setting aside the protests made within the last three months against a sale such as the Commissioners have been opposed to.

It is therefore difficult to escape from some such conclusion as this: that the projected sale of the inner gardens of the estate for private building speculations will be an autocratic act utterly ruinous to the character of the Commissioners; and that the Commissioners persist in defending and urging this act by pleas and arguments stoutly opposed by themselves twelve years ago.

[1] "The following is an extract from our Second Report, dated in 1852:—'A large number of suggestions and applications, in reference to the d.sposal of the surplus, have been made to the Commissioners. . . . The answer which the Commissioners have returned to the different applications submitted to them has been to show, by reference to their preliminary Report to Her Majesty, of the 6th of November of last year, that they do not feel themselves to be in a position to comply with proposals which involve the surplus being applied to purposes of a limited, partial, or local character, or to returning to the different localities, in order to be there appropriated to local public objects connected with the progress of art, science, and education, the amount of subscriptions originally raised in each place, which subscriptions were at the time made on the clear understanding that they must be "absolute and definite." The Commissioners would call especial attention to the memorials from the important manufacturing and commercial towns of Birmingham, Bristol, Halifax, Hull, Oldham, Sheffield, and the Staffordshire Potteries, which are appended to this Report, and indicate clearly the strong feeling entertained by those well entitled to form an opinion on this subject, of the importance of establishments for instructing those engaged in trade and manufacture in the principles of science and art on which their respective industries depend.' The towns mentioned presented memorials praying for the establishment of a Central Institution of Arts and Manufactures."

THE INTERNATIONAL CHEMICAL CONGRESS.

AN International Chemical Congress has just been held in Paris under the presidency of M. Berthelot. The Congress was composed of some 300 members, including the most eminent French chemists, and a certain number of distinguished foreigners. It was much regretted that foreign countries should not have been more numerously represented, and it was explained that owing to the protracted illness of M. Hanriot, Secretary of the Paris Chemical Society and of the Congress, the invitations were not sent out till very late, and still further delay was caused by their passage through the Ministry of Public Instruction. Much credit is due to M. Fauconnier, who undertook to replace M. Hanriot at the last moment.

The opening meeting was held on the 29th ult. at the Conservatoire des Arts et Métiers, the proceedings being of a purely formal character. M. Berthelot, who occupied the chair, said that a large number of communications had been received by the organizing Committee, and that from the nature of these communications it had been found expedient to divide the Congress into four Sections, which he proceeded to enumerate, together with the list of Sectional Presidents and Secretaries proposed by the Committee :—

Section I. Analysis of Food-Products : President, M. Riche ; Secretary, M. Bishop.

Section II. Analysis of Agricultural Products : President, M. Joulie ; Secretary, M. Demoussy.

Section III. Analysis of Pharmaceutical Products : President, M. Petit ; Secretary, M. Bocquillon.

Section IV. Unification of Chemical Nomenclature : President, M. Friedel ; Secretary, M. Bouveault.

The Sectional meetings took place in the day-time ; the evenings of July 30, August 1, 2, and 3, being reserved for the discussion of the reports presented by the various Sections.

Section I.—The Section discussed a certain number of methods used in the analysis of flour, bread, wine, coffee, &c. At the general meeting the following resolutions were passed :—

(1) That the Government be requested to inspect regularly the factories of salted meats, as at present the brines used are added to constantly, but never changed (report by M. Combes).

(2) That the Government be requested to inspect all teas on their entry into France.

(3) That not more than 0·3 per cent. of lead should be permitted in the alloy used for "tinning," nor more than 5 per cent. in the alloy for tin vessels.

(4) That it is desirable that the methods of wine analysis should be verified and codified.

Section II.—After discussion of the methods at present in use for the analysis of earths, manures, &c., it was resolved that in the case of judicial disputes no single method should in any case be obligatory,[1] but that the fullest latitude should be allowed to the experts.

Section III.—It was resolved that a certain number of permanent Commissions should be appointed for the inspection of some of the most important substances used in pharmacy—quinine, morphine, chloroform, phenol, salicylic acid, analgesine, &c. The Commissions should endeavour to investigate and improve the methods of analysis used for these substances.

Section IV.—Section IV. was the one of by far the greatest general interest, as was testified by the presence of Profs. Alexeieff (Kiew), Calderon (Madrid), Franchimont (Leyden), Graebe (Geneva), Istrati (Bucharest), Noelting (Mulhouse), Boukowski Bey (Constantinople), and Colonel da Luz (Rio Janeiro), who were elected Vice-Presidents.

[1] The Comité Consultatif des Stations Agronomiques et des Laboratoires Agricoles has issued a code of the methods of analysis of manures, and these are at present obligatory.

The following is a short account of the discussions held at the Sectional meetings :—

The Nomenclature of Unsaturated Hydrocarbons.—M. Calderon read a paper, in which he proposed to replace the present arbitrary names of the hydrocarbons by a series of names derived from the fundamental terms of each series. He proposes to name paraffins, *proto-methane*, *deuto-methane*, &c., the olefines *deuto-ethylene*, *trito-ethylene*, &c. The radicles are derived from the hydrocarbons by the insertion of Latin numerals between the Greek numeral and the generic name ; thus, methyl becomes *proto-uni-methane*, &c. The author advocated these changes as calculated to facilitate the teaching of organic chemistry.—MM. Friedel, Grimaux, Graebe, and Maquenne expressed the view that it was impossible to make changes so radical, and that Hofmann's nomenclature was quite sufficient so far as the normal hydrocarbons are concerned.

M. Béhal presented a report to the Section on a system for the nomenclature of complex open-chain compounds. He regards them as formed by the addition of characteristic groups (*groupements fonctionnels*),[1] in which certain atoms of hydrogen are replaced by various radicles. These radicles are given in the order of the number of carbon atoms they contain, starting with the lowest. To denote different isomers the Greek letters, α, β, γ, δ, are employed. One or two examples may be given. The body

$$CH_3{-}CO{-}C{\equiv}C{-}CH_2{-}CHO$$

would be called acetyl-acetylene-ethaldehyde (acétyl-acétylène aldéhyde éthylique). The body

$$\begin{matrix} CH_3{-}CH_2{-}CO\diagdown & & \diagup COOH \\ & C{=}C{=}C & \\ CH_3{-}CO\diagup & & \diagdown CH_3 \end{matrix}$$

would be called acetyl propionyl allene[2] methyl formic acid.—Many objections were raised to M. Béhal's proposition by MM, Friedel, Graebe, Grimaux, and others, and it was finally decided to refer it to the Permanent Committee.

Derivatives of Ethylene and Urea.—M. Graebe proposed to denote the two atoms of carbon in ethylene derivatives, united by the double bond, by the letters *a* and *b*. If two similar radicles are introduced into the ethylene molecule, as, for example, in dimethyl ethylene, the two isomers would be called *ab*-dimethyl ethylene and dimethyl ethylene, or for greater clearness *a*-dimethyl ethylene. In the case of trisubstituted compounds it should be understood that the first two radicles were linked to the same carbon atom.—M. Franchimont proposed to adopt the same nomenclature for the urea derivatives. —Attention was drawn to the possibility of new isomers, if Wislicenus's extension of the Van 't Hoff-Lebel hypothesis should be proved to be of general application, but it was decided for the present not to number the four atoms of hydrogen in ethylene, and M. Graebe's proposition and M. Franchimont's rider were adopted.

Aldehydes.—M. Grimaux proposed a resolution recommending that in future aldehydes should be named after the corresponding alcohols, and not after the acids. He pointed out that this usage was consistent with the etymological origin of the word, and that the practice of giving the same name to alcohols and their corresponding acids would give rise to confusion in the names of the acid and hydrocarbon radicles which they contain ; the names corresponding to ethyl and acetyl, to benzyl and benzoyl, would become identical if we used the names

[1] In France the word function is used in the following sense. Methyl alcohol gives rise by substitution to compounds whose chemical behaviour is similar to its own, and are therefore said to have the same chemical *function*. The group $CH_2 . OH$ is thus characteristic of the *primary alcohol function* ; similarly, the group $C{=}C$ of the ethylene function, the group $H . C{=}O$ of the aldehyde function, &c., &c.

[2] Or isoallylene.

ethylic alcohol, ethylic acid, benzoic alcohol, benzoic acid. —M. Grimaux's proposition was adopted.

The Use of the Prefixes bi- and di-.—M. Bouveault proposed, in the name of M. Hanriot, that the prefix *bi* should be reserved for the denomination of bodies formed by the duplication of organic radicles; the words dipropargyl, diphenyl, dinaphthyl to be replaced by bipropargyl, biphenyl, binaphthyl.[1] M. Maquenne preferred to use *di* instead of *bi* for these double radicles; but it was pointed out that there were only about twelve bodies whose names would need to be changed to be in harmony with M. Hanriot's proposition, whereas the converse proposition would be much more difficult of adoption.—M. Grimaux thought that in any case it would be difficult to alter existing nomenclature at once, but proposed that the Congress should express a wish that M. Hanriot's system of nomenclature should be adopted for all new bodies, and should gradually replace the existing one.—M. Grimaux's modification of M. Hanriot's proposition was adopted.

The Use of the Suffix -ol.—M. Grimaux proposed that the suffix *-ol* should be restricted as far as possible to the alcohols, and that the names of all hydrocarbons should contain the letter *n*. He proposed that the ending *-ene* employed by English chemists, should be made use of for the aromatic hydrocarbons. *Benzine* and *naphtaline* in French, *benzol* in German, would be replaced by the English terms benzene and naphthalene.—M. Graebe warmly supported this proposition, and further suggested the abbreviation of naphthalene to *naphthene.*—M. Grimaux's proposition was adopted.

Ketones.—M. Friedel pointed out the ambiguity which exists in the French nomenclature of the acetones. Dimethyl acetone might mean either the body $CO(CH_3)_2$ or else $CH_3-CH_2-CO-CH_2-CH_3$ (or its isomer). He proposed to adopt the German notation for these bodies, and in general to replace the word *carbonyl* by the word *cetone* (this form being more adapted to the French language than ketone). Dimethyl cetone is then ordinary acetone. —The proposition was adopted.

The Group —C☰N.—M. Bouveault proposed to name this group *carbazil.*—M. Calderon and other members of the Congress were in favour of this name. It was also proposed to use the word *nitrile* universally.—M. Grimaux then pointed out that, as we made no distinction of nomenclature between the molecule and the half-molecule of chlorine, it would be unnecessary to do so in the case of cyanogen, and he proposed that the group —C☰N be denoted by the name cyanogen.—M. Grimaux's proposition was adopted.

The Sulphur Compounds.—M. Chabrié read a report on the sulphur compounds. He complained that a certain number of chemists used the term *sulphine* for compounds containing no oxygen, and which should properly be termed sulphides. He proposed that the name sulphine should be reserved for compounds of the formula $(SO)R_2$, sulphones for compounds $(SO_2)R_2$, derived respectively from sulphurous and sulphuric acids. This nomenclature is used by Beilstein in his invaluable compilation. It is naturally applicable to corresponding selenium and tellurium compounds.—It was decided to refer M. Chabrié's report to the Permanent Committee.

Ring Formulæ containing Nitrogen.—M. Bouveault read a long report on the subject. He proposed to adopt Widmann's nomenclature, with certain modifications in the details.—A protracted discussion ensued, and finally M. Graebe proposed that M. Bouveault's report should be printed and widely distributed, so as to elicit the opinion of all the chemists who had specially devoted themselves to the study of these compounds, and this was agreed to.[1]

Naphthalene.—M. Noelting read a report on the nomenclature of the naphthalene derivatives. He began by describing the various notations of Beilstein, Graebe and Noelting, Meldola, Weinberg, and the Swedish chemists. He proposed to denote the carbon atoms of the naphthalene ring by figures and to extend this system to anthracene, phenanthrene, &c. M. Noelting's proposal was adopted after discussion. The figures will be found below in the summary of the resolutions of the Congress. —It was agreed, on the suggestion of M. Auger, that when it was known that the radicles of a given di-substituted compound were in different rings, but their exact position was uncertain, they should be denoted by the symbol AB.

Benzene.—M. Combes read a report on the numeration of substituted benzene derivatives. He proposed to assign the place (1) to the hydrocarbon radicle containing the smallest number of atoms of carbon: in the absence of a hydrocarbon radicle he proposed to begin with the group having the lowest "molecular weight."—M. Combes gave as the reason for choosing the simplest hydrocarbon for the position (1) that it was this one which was generally attacked last by oxidizing agents.

M. Alexeieff pointed out that the oxidation of paracymene, $C_6H_4 . CH_3 . C_3H_7$, by the action of air and caustic soda, gives rise to cuminic acid, $C_6H_4 . CO_2H . C_3H_7$, and that in this case the position (1) would be changed, although there was no transposition in the molecule.[2]

M. Combe's report was referred to the Permanent Committee.

The general meeting for the discussion of the report of Section IV. was held under the presidency of M. Friedel, in the absence of M. Berthelot.

The following resolutions were adopted:—

(1) That an International Committee, with power to add to its number, be formed, whose object shall be to promote uniformity of chemical nomenclature.

The following gentlemen were nominated to serve on the Paris Committee:—MM. Berthelot, Friedel, Gautier, Grimaux, Jungfleisch, Béhal, Bouveault, Combes, Fauconnier.

That the Committee shall immediately request the following gentlemen to join them:—MM. Alexeieff (Russia), Armstrong (England), Baeyer (Germany), Beilstein (Russia), Boukowski Bey (Turkey), Calderon (Spain), Clève (Scandinavia), Franchimont (Holland), Graebe (Switzerland), Istrati (Roumania), Lieben (Austria-Hungary), Noelting (Germany), Paternò (Italy), Ira Remsen (United States).

(2) The two carbon atoms in ethylene, and the two hydrogen atoms in urea, shall be distinguished by the letters *a* and *b* (proposed by MM. Graebe and Franchimont).

(3) The aldehydes shall be named after their corresponding alcohols (proposed by M. Grimaux).

(4) The word carbonyl shall be replaced by the word cetone[3] (proposed by M. Friedel).

(5) The group —C☰N in organic compounds shall be called cyanogen, instead of nitrile (proposed by M. Grimaux).

(6) The suffix *-ol* shall be reserved as far as possible for alcohols. In the hydrocarbons it is to be replaced by the ending *-ene* (proposed by M. Grimaux).

(7) The prefix *bi-* shall in future be reserved for bodies formed by the union of two radicles such as biphenyl $(C_6H_5)_2$, bipropargyl $(C_3H_3)_2$, and the Congress expresses

[1] It may be mentioned that whereas in England the use of the prefix bi- has been almost entirely abandoned, in France it is still employed, though no rules for its use have hitherto been given; the terms *di-nitro benzine* and *benzine bi-nitré* denote the same body.

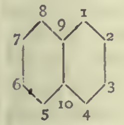
[1] The nomenclature of the pyridine and quinoleine derivatives agreed to by the Section was afterwards referred back to the Committee.

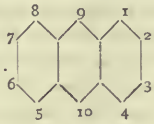
[2] It may be remarked that this difficulty is inherent to the case, since the oxidation of paracymene by chromic acid gives rise to paratoluic acid.

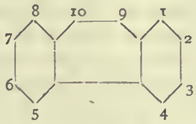
[3] This applies only to French nomenclature.

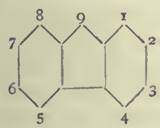
the desire that this nomenclature may be gradually adopted for bodies already known; the prefix *di-* to be used as at present, to denote bodies formed by double substitution (proposed by M. Hanriot).

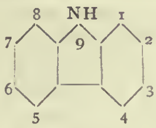
(8) The different carbon atoms of naphthalene anthracene, phenanthrene, fluorene, carbazol, acenaphthene, acridine, shall be numbered as follows:—

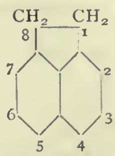

Naphthalene.

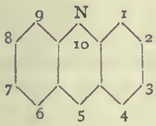

Anthracene.


Phenanthrene.


Fluorene.


Carbazol.


Acenaphthene.


Acridine.

(Proposed by M. Noelting.)

(9) The proposition to denote the carbon atoms of quinoleine by *α*, *β*, *γ* for the pyridine ring, and *o*, *m*, *p*, *a* (ortho, meta, para, ana) in the benzine ring,[1] which had been voted at the Sectional meeting, was adjourned by a vote of 42 against 26, and referred to the Permanent Committee.

After the carrying of the resolutions, M. Friedel made a short speech, in which he thanked especially the foreign members for their attendance and help. Some people might, he said, think that the Section had accomplished but little; that, however, was not his opinion: their aim had been to help workers in their work, and nothing could be more conducive to this aim than the use of the same language among the chemists of all countries. He felt sure that their efforts would prove fruitful in the future, and he hoped that by next year the International Committee would be able to report such serious progress as to justify the summoning of another Congress.

Thus terminated the formal proceedings of the Section and Congress, which had been marked throughout by the greatest good feeling among the *savants* of the various nations represented. On Sunday the Congress was brought to a final close by a banquet offered to the foreign members at the Terminus Hotel.

[1] Lellmann's notation.

THE REV. M. J. BERKELEY.

THE death of our great English mycologist has followed very close upon that of our great English lichenologist. Both of them were country clergymen of the Church of England, both were over eighty, and the career of both as botanical authors has extended over half a century.

The Rev. Myles Joseph Berkeley, M.A., F.R.S., was born at Biggin, in the parish of Oundle, in the year 1803. He was a descendant of the old historic family of that name. He was educated at Rugby, and at Christ's College, Cambridge, and graduated as fifth Senior Optime in the year 1825. After holding a curacy at Margate, he was appointed, in 1833, incumbent of two small parishes near Wansford, in his native county. Here he remained for thirty-five years, actively engaged in the performance of his parochial work. His stipend was small and his family large, and he had to supplement his clerical income by taking private pupils. This of course absorbed a great deal of his leisure, but his industry and force of character were so great that he got through, in addition, an enormous amount of scientific work. In 1868 he was appointed to the more valuable living of Sibbertoft, near Market Harborough, which he held until his death, on July 30. During the last ten years his health has failed, and in 1879 he presented his botanical collections to Kew, and, since that time, has published scarcely anything.

His attachment to botany must have begun very early in life, for I remember him saying, when we were speaking about a certain botanical examination, that he had not set any questions that he could not have answered when he was six years old. His friends thought he would have taken a higher degree at Cambridge if he had not given so much attention to natural history. His first book, "Gleanings of British Algæ," appeared in 1833. It deals mainly with minute microscopic types. The book which made his reputation was his "Monograph of the British Fungi," which forms the third volume of Hooker's "British Flora," published in 1836 This was the only hand-book of the British species in existence up to 1871, so that for thirty-five years it was the indispensable companion of every worker. The "Systema Mycologicum" of Fries, which summarized most ably all that was then known about genera and species, came out —the three volumes from 1821 to 1829, its "Supplement" in 1830, and the "Elenchus" in 1828; so that these were just in time to serve Berkeley as a foundation to build upon. From 1836 to 1870 he was the universal referee for everyone in this country who wanted information about fungi. Collections poured in upon him from home and abroad, and he described many thousands of genera and species, a large proportion of which were new, in Hooker's "Antarctic Floras," Hooker's *Journals of Botany*, the Transactions and Journal of the Linnean Society, and in the *Annals of Natural History*. During the latter part of the time he worked a great deal in conjunction with the late Mr. C. E. Broome, of Bath, who had abundant leisure and industry, combined with an unconquerable disinclination to publish on his own account, and in every Fungus-list "Berk. et Broome" is an often-quoted authority. Beginning with *Oidium Tuckeri*, he gave special attention to the fungoid pests of agriculture and horticulture; and it was, more than anything else, his papers on the potato disease that obtained for him the small pension that was granted to him during the last twenty years of his life. In 1857 he published a general "Introduction to Cryptogamic Botany," which has had a wide circulation. There has been no other book of a similar scope in the English language till this present year. His "Outlines of British Fungology," published in 1860, contains twenty-four plates, illustrating a series of about 150 typical forms. The text deals specially with the Hymenomycetes, and, for the other orders, does not go much beyond a catalogue of the British genera and species. His "Hand-book of the British Mosses," published in 1863, contains descriptions and plates of all the species then known in Britain. In the same year he was awarded the Biological Gold Medal of the Royal Society, of which he was elected a Fellow in 1879. But by this time his working days were over, and in that year he presented to Kew his entire fungus herbarium, followed, not long after, by his books. His herbarium contains specimens of upwards of 10,000 species, duly named and classified; and it has been estimated by Mr. G. E. Massee that it contains type specimens of 4866 species described by himself, and that the full number of new species which he described will not fall far short of 6000.

For many years he acted as one of the botanical examiners of the University of London, generally in conjunction with Sir J. D. Hooker and the late Dr. Thomson; and he acted also in the same capacity for the University of Cambridge and the Apothecaries' Company.

From the commencement of the *Gardener's Chronicle*, in 1841, till his health failed, he was a regular contributor to its pages. His most important papers were a series of articles on vegetable pathology, commenced in 1854 and continued at intervals till 1857. He also contributed a series of articles on the diseases of plants to the "Cyclopædia of Agriculture." He was one of the first to lay special stress upon the need for studying the full life-history of a fungus in order to understand it properly, the carrying out of which in the last generation has so completely changed many of our old ideas.

After the death of Lindley he acted for many years as botanical referee and general counsellor to the Royal Horticultural Society, a post for which he was well fitted, from his thorough knowledge of vegetable physiology and his acquaintance with practical gardening. It was in the Journal of this Society that his papers on the potato disease appeared. He was an excellent classical scholar, and read through all the proof-sheets of Bentham and Hooker's "Genera Plantarum," specially as linguistic critic. He was a man full of geniality, always willing to impart freely his wide store of information, and will be greatly missed by those that had the pleasure of his personal acquaintance. He had a commanding presence and a robust physique. His portrait, painted in oil by Peel in 1878, now hangs in the rooms of the Linnean Society, and a capital full-page engraving, by Mr. Worthington Smith, has twice appeared in the *Gardener's Chronicle*.

J. G. B.

NOTES.

We mentioned last week the *fêtes* in connection with the opening of the new Sorbonne, to which students from all the Universities of Europe had been invited. The following is a complete programme of the ten days' festivities—held under the auspices of the Association Générale des Étudiants de Paris—in which all the students of Paris, as well as their foreign guests, were invited to take part:—August 4, gala performance at the Opera. August 5, inauguration of the Sorbonne; reception by M. Fallières, Minister of Public Instruction. August 8, reception by the Municipality of Paris at the Hôtel de Ville. August 9, *matinée* at the Comédie Française; reception by M. Yves Guyot, Minister of Public Works; reception of the English and American students by M. Beljame, Professor of English at the Sorbonne. August 10, speeches by the chiefs of the foreign delegations; performance at the Gaîté Theatre. August 11, presentation of the chiefs of the foreign delegations to M. Carnot. August 12, ascent of the Eiffel Tower; excursion to Meudon; banquet on the terrace, under the presidency of M. Janssen. The *fêtes* have been throughout a magnificent success, and the students of all countries must carry away with them the most pleasant of remembrances of their French comrades. The Government and the City of Paris had voted a sum of about £3500 to the Association Générale des Étudiants, and it is to the organizing powers of the President, M. Chaumeton, and his devoted lieutenants, that the success of the meeting is due. At the Meudon banquet, at which there were nearly 2000 covers, M. Lavisse, Professor of Modern History at the Sorbonne, in an eloquent speech, declared that the principle of the future must be, not cosmopolitanism, but "*le respect de chaque patrie par toutes les patries.*"

The Congress of Physiological Psychology was held in Paris last week, and the meeting is considered to have been very successful. It was decided that a second meeting should be held in 1892, either in London or in Cambridge, during the month of August.

The Hygiene Congress at Paris brought its labours to a close on Saturday last. Among the subjects discussed during the week was that of the pollution of rivers. The Congress decided that the pollution of underground watercourses and of rivers by the residue of factories should in principle be forbidden, and that water from factories should not flow into a stream till it had been proved to be absolutely free from all injurious substances. The Congress was strongly of opinion that the most perfect method of purification was by irrigation. This, of course, must, in certain cases, be preceded by such mechanical and chemical processes as would render the water fit for agricultural purposes. It was related that many manufacturers had benefited by the application of the law, as in their efforts to prevent the pollution of watercourses they had made discoveries enabling them to utilize waste products. The difficulty was with the smaller manufacturers, who were not rich enough to take the necessary measures. The Congress decided that where persistent resistance was displayed the authorities should themselves execute the works prescribed for the purification of the water and compel the persons interested to pay the cost.

Arrangements are being made by the local committee of the American Association at Toronto for an excursion, starting September 3 or 4, to the Huronian district. Particulars will be given in a circular, which is to be issued by the American Geological Society. There will also be an excursion to the Pacific Coast.

Some time ago the Berlin Academy of Sciences received from Count Loubat, of New York, about £1150, with a request that a prize might be founded for the encouragement of North American studies. At the same time he sent £120, which was to be offered as a special prize. It has now been decided that a prize of £150 shall be awarded in July 1891, to the author of the best printed work on the settlement of civilized colonies in North America and their later history. The works to be submitted must have appeared between July 1, 1884, and July 1, 1889; and the authors must communicate to the Berlin Academy before July 1, 1890, their intention to compete. The language of the books may be German, English, French, or Dutch. In 1896 there will be another prize of similar amount for a work on the North American aborigines. Every five years a prize of £150 will be offered, the subjects being aboriginal and civilized history, chosen alternately. The money for the first of this series of prizes will be obtained by the addition of the special sum of £120 to the interest on the larger and permanent fund.

The Royal Danish Academy of Sciences invites research on the following among other subjects:—Compounds of alcohol radicals with copper, silver, or gold, and compounds of polyvalent alcohol radicals with metals (all unknown at present). Prize a gold medal. The fatty acids in the fat of butter; to be isolated and determined, and relations indicated especially between the quantities of oleic acid and those of palmitic acid and their higher homologues. Prize about £32. The Mycorhizæ of the beech. Are they different in different kinds of humus? Does the structure of the mycelium give a basis for classification? Is there a reciprocal symbiosis, the fungus preparing food for the plant, &c., &c. Prize about £32. Memoirs to be sent to Prof. Zeuthen, of Copenhagen, before October 31, 1890, except in the last case, for which the date is October 31, 1891.

The twelfth annual meeting of the Midland Union of Natural History Societies will be held at Oxford on the afternoon of Monday, September 23. An inaugural address, on heredity, will be delivered by the President, Mr. E. B. Poulton, F.R.S. This will be followed by a discussion, after which the meeting will transact all necessary business. In the evening there will be a *conversazione* in the Museum, and the Oxfordshire

Natural History Society and Field Club has arranged for exhibitions of objects of great interest. On the following day members will drive to Shotover Hill, and a lecture will be delivered by the President on "the geology of the district." Afterwards there will be a lunch in Christ Church dining hall. Special arrangements will be made for members to visit, on this and also on Monday afternoon, the following places:—Museum, Ashmolean Museum, Radcliffe Observatory, Botanic Gardens, Bodleian Library, and Clarendon Printing Press. The Oxford Society cordially invites members of natural history societies, and their friends, to the meetings of the Union; and no doubt so pleasant a programme will attract a very large number of visitors. Further information may be obtained from the Secretary, Mr. H. M. J. Underhill, 7 High Street, Oxford.

A useful little volume relating to the approaching meeting of the British Association has been issued at Newcastle. It contains, in addition to the programme and other information, memoirs (reprinted from the *Newcastle Daily Chronicle*) of the President, the Presidents of Sections, and the lecturers. The volume costs threepence, and will, of course, be widely circulated. There has also been issued, for the use of those who propose to attend the meeting, a list of the hotels, apartments, and furnished houses, with a plan of Newcastle.

Mr. George Phillips Bevan, F.G.S., died on the 3rd inst. at Yaldhurst, Lymington, in his sixtieth year. He was the author of many popular hand-books and guide-books. He also wrote industrial geographies of Great Britain, France, and the United States, and edited a series of works on "British Manufacturing Industries."

The American *Botanical Gazette* announces the death of Mrs. Lydia S. Bennett, a well-known botanist at Fisk University, Tennessee.

On August 12, about 3 o'clock a.m., a rather severe shock of earthquake was felt at Poitiers. Clocks were stopped, and furniture was displaced. No one was injured.

The German edition of the Report of the International Meteorological Committee meeting at Zürich, in September last, contains a preface by Dr. Neumayer, relating to the development of meteorological research in Germany, which, prior to the Congress of Vienna (1873), was almost at a standstill, very little attention having been paid to what was passing in other countries. But the impulse given by that Congress and various meetings of the Committee, together with the establishment of the Deutsche Seewarte at Hamburg and the Meteorological Institute at Berlin, have made the German-speaking countries rank among the foremost and most active promoters of meteorology, all now working together on one uniform plan. The Report contains also a very useful index to all the German editions of the publications of the International Meteorological Committee since the Congress of Rome (1879). A mere glance at this index shows the generality and usefulness of the labours of the Committee, exclusive of the meetings in some way connected with it, among which may be specially mentioned those of the Polar Committee (Hamburg, 1879), and the Conference for Agricultural Meteorology (Vienna, 1880). The preparation of meteorological bibliographies, the establishment of stations in remote parts of the world and upon high mountains, the preparation of elaborate meteorological conversion tables (not yet published) for use in all countries, and uniformity of methods, are but a few of the principal results arrived at in the last sixteen years.

One of the latest novelties in the application of electricity consists of an electric reading-lamp, which is being fitted to the carriages on the main line of the South-Eastern Railway. It is on the principle of the "put a penny in the slot" automatic machines. The apparatus is situated immediately over the passenger's head, and under the rack, and is contained in a small box 5 inches by 3. The light is of five-candle power, and is obtained by the introduction of a penny at the top of the box, and by a subsequent pressure of a knob, and will last for half an hour, extinguishing itself at the end of that time automatically. If the light be required for an indefinite period, a penny every half an hour will suffice. The light can be extinguished at any moment by means of a second button provided for the purpose. One of the special features of the invention is that, if the instrument is out of order, the penny is not lost, as it is in the present machines. It drops right through, and comes out at the bottom of the box, so that it can be recovered, and the same result happens in the case of any coin other than a penny. Each carriage is fitted with an accumulator which supplies the electricity. This invention will add greatly to the comfort of passengers during night journeys.

Some new light on the subject of indirect vision (*i.e.* vision with the lateral parts of the retina), is thrown by recent experiments made by Kirschmann. The common idea, that the sensitiveness of the retina diminishes outwards to the periphery, appears to be incorrect. There is an objective diminution of light-action, when a source of light is moved away laterally from the middle of the field of vision; for the mass of penetrating light gets less. Hence, were the diminishing sensitiveness a fact, a luminous surface should seem to lose brightness when moved to the side; but it does not (though it appears less distinct in outline and modified in colour). Kirschmann placed two rotatory disks made up of moveable black and white sectors (giving any degree of brightness), before the observer; who shut one eye, and looked at the middle of one disk, about a metre and a half from him, while he gave his attention to comparing the brightness of the second disk, seen at different angles, by indirect vision. The figures from numerous experiments prove that, in the horizontal meridian, the sensibility to brightness has a maximum at 22° to 25° from the centre, while in the vertical direction the maximum is at 12° to 15°. The growth of sensibility is much greater in the horizontal than in the vertical direction, and the upper part of the retina is superior in this respect to the lower. This corresponds to the needs of vision. Indirect vision with lateral parts of the retina is more important than that with the upper and lower regions; and the upper half is more important than the lower.

Messrs. Macmillan have issued a new volume of the "Nature Series"—"Timber and some of its Diseases," by H. Marshall Ward, F.R.S. Until the author's articles appeared in this journal, the subject, as he says in his preface, was almost unknown in England.

A suggestive paper, on "The Ta Ki, the Svastika, and the Cross in America," by Dr. Daniel G. Brinton, is printed in the new number of the Proceedings of the American Philosophical Society. He holds that all these symbols are graphic representations of the movements of the sun with reference to the figure of the earth, as understood by primitive man everywhere, and hence that these symbols are found in various parts of the globe without necessarily implying any historic connections of the peoples using them.

The Geological and Natural History Survey of Minnesota has issued its sixteenth Annual Report, dealing with such results of its work as are capable of being put into a shape fit for publication. Mr. Winchell, State Geologist, says in an introductory statement that investigations are being carried forward in the lithology of the crystalline rocks and in the palæontology of the fossiliferous ores, which are not yet sufficiently far advanced to be dealt with in a Report.

In a valuable paper, included in the Annual Report of the United States Department of Agriculture for 1888, on the plum

Curculio, Messrs. C. V. Riley and L. O. Howard state that this insect has brought about an almost entire abandonment of plum culture in many parts of America within the last twenty years; but it is by no means confined to this fruit. It breeds in great numbers in cherries, peaches, apricots, nectarines, and other stone fruits, including the Persimmon, and also infests many varieties of apples, crabs, and haws. It prefers, however, smooth-skined fruits. It is also a common inhabitant of the fungus growth of plum and cherry known as "Black Knot" (*Plowrightia morbosa*), from which it was first reared by Peck in 1818. Under the headings, "Habits and Natural History," "Natural Enemies," and "Remedies," the authors of the paper (which has just been reissued separately) give full information as to the pest to which they have devoted so much attention.

THE "Catalogue of the Moths of India," on which the compilers, Colonel C. Swinhoe and Mr. E. C. Cotes, have been engaged for three years, is completed; and an elaborate index has now been published. The compilers claim that the "Catalogue" comprises all the known moths of the Indian region, including Burma and Ceylon.

THE *Madras Journal of Literature and Science*, for the session 1888–89, contains, besides various other papers, the second part of an elaborate treatise, by Gustav Oppert, on the original inhabitants of India. In the first he treated of the Dravidians; here he deals with the other aboriginal tribes, whom he classes together under the name of the Gaudians. In the third part he proposes to set forth various conclusions to be drawn from this inquiry, supported by as much trustworthy evidence as he may be able to collect.

THE University Correspondence College, Cambridge, has sent us a copy of its latest "Matriculation Directory." The volume is full of information that will be useful to persons who propose to pass the matriculation examination of the London University. In the parts relating to text-books, much excellent advice is offered to candidates.

THE Mason Science College, Birmingham, has issued its syllabus of day classes for the session 1889–90.

THE Agricultural Society of the Gironde, as quoted in a recent British Consular Report, has published a statement showing the average costs incurred last year by proprietors in this department in employing the best-known remedies, viz. (1) against the *Phylloxera*, sulphuretted carbon; (2) against mildew, the so-called *Bouillie Bordelaise*, a mixture of three pounds of sulphate of copper with one pound of slaked lime and twenty-two gallons of water; (3) against *Oïdium*, sulphur; and (4) against *Antrachnosis*, a mixture of eighty pounds of sulphate of iron and ten pounds of sulphate of copper. The total cost of using all these remedies is said to have amounted on an average to about 31*s*. per acre, an expense which cannot be called excessive, especially when it is added that their application served at the same time as a preventive against snails and slugs, which also often do much damage to vines.

Globus contains an abstract of a paper read lately before the German Scientific Association of Santiago, on the inhabitants of Tierra del Fuego, by the Rev. C. Aspinall, an English missionary who has laboured long among them. The particular tribe amongst which the Ooshonia mission was established has received from Mr. Bridges the name of Jahgan, from a place to the south of Beagle Channel frequented by the tribe. The people usually go naked, save for a small skin thrown over the shoulders, but they smear their bodies with a mixture of train-oil and red earth as a protection against the cold. They support themselves by hunting, and at the worst feed on shell-fish. Certain disorders of the digestion, arising from the latter, they cure by a fungus diet. For the most part they move about from place to place, without any fixed abode, in bark canoes, in the centre of which a fire always burns. Each canoe contains a family, the wife rowing while the husband is always on the watch with his javelin. He always carries three kinds of spears with him, one for birds, the second for fish, and the third for crabs. On landing, the woman has first of all to carry her husband ashore, he holding the fire carefully above water, and then she begins the erection of their primitive hut. The men are rarely able to swim, but the women invariably, and this, together with their constant work at rowing, gives them extraordinary muscular power. To maintain their position as lords of creation the men have recourse to mysterious rites, from which the women are excluded. The men have usually two wives, an older and a younger one. Without writing of any kind, they yet preserve many rules and customs, mainly relating to the chase. They are good-natured and helpful, not addicted to lying or theft, but tenacious in the defence of their rights. They have many amiable traits of character. They love long stories and conversations, and in these a good part of their time is spent. One of their tales, of an extraordinary strong man who was made of stone, and ultimately was killed by a thorn entering a vulnerable spot in his heel, recalls the story of Achilles. Devoid of all religious ideas and duties, they have a vague idea of the spirits of the departed wandering about in the world, and greatly to be feared.

THE additions to the Zoological Society's Gardens during the past week include a Gazelle (*Gazella dorcas* ♂) from Egypt, presented by Mr. Umberto Arbib; a Cinereous Vulture (*Vultur monachus*) from Central Spain, presented by Lord Lilford; two Vinaceous Turtle Doves (*Turtur vinaceus*) from West Africa, presented by Mrs. Ffoulkes; two Alligators (*Alligator mississippiensis*) from Florida, presented by Mr. J. W. Bannehr; twenty-two Gold Fish (*Carassius auratus*), four Carp (*Cyprinus carpio*), British fresh waters, presented by Mr. A. H. Hastie; a Cinereous Vulture (*Vultur monachus*) from Central Spain, a Grey Parrot (*Psittacus erithacus*) from West Africa, twenty-four Teydean Chaffinches (*Fringilla teydea*) from the Canary Islands, deposited; a Globose Curassow (*Crax globicera*), two Triangular Spotted Pigeons (*Columba guinea*), two Cambayan Turtle Doves (*Turtur senegalensis*), bred in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 AUGUST 18–24.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 18

Sun rises, 4h. 52m.; souths, 12h. 3m. 35·1s.; daily decrease of southing, 13·3s.; sets, 19h. 15m.: right asc. on meridian, 9h. 51·8m.; decl. 12° 58′ N. Sidereal Time at Sunset, 17h. 4m.

Moon (at Last Quarter August 18, 11h.) rises, 22h. 18m.*; souths, 5h. 39m.; sets, 13h. 13m.: right asc. on meridian, 3h. 26·4m.; decl. 14° 48′ N.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	5 48 ...	12 46 ...	19 44 ...	10 34·0 ...	10 33 N.
Venus.....	1 10 ...	9 11 ...	17 12 ...	6 58·5 ...	21 9 N.
Mars......	3 2 ...	10 52 ...	18 42 ...	8 39·9 ...	19 31 N.
Jupiter....	16 11 ...	20 4 ...	23 57 ...	17 53·5 ...	23 25 S.
Saturn....	4 38 ...	11 59 ...	19 20 ...	9 47·1 ...	14 36 N.
Uranus...	9 55 ...	15 23 ...	20 51 ...	13 11·4 ...	6 56 S.
Neptune..	22 34*...	6 24 ..	14 14 ..	4 11·2 ...	19 26 N.

* Indicates that the rising is that of the preceding evening.

Aug.	h.	
22 ...	22 ...	Venus in conjunction with and 1° 59′ south of the Moon.
24 ...	18 ...	Mars in conjunction with and 1° 29′ south of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.
Algol	3 1·0	40 32 N.	Aug. 22,	3 32 *m*
δ Libræ	14 55·1	8 5 S.	,, 22,	1 14 *m*
U Ophiuchi	17 10·9	1 20 N.	,, 23,	3 10 *m*
			,, 23,	23 18 *m*
X Sagittarii	17 40·6	27 47 S.	,, 19,	0 0 *M*
W Sagittarii	17 57·9	29 35 S.	,, 23,	4 0 *m*
T Herculis	18 4·9	31 0 N.	,, 20,	*m*
U Sagittarii	18 25·6	19 12 S.	,, 22,	0 0 *m*
			,, 24,	23 0 *M*
β Lyræ	18 46·0	33 14 N.	,, 23,	1 0 m_2
R Lyræ	18 52·0	43 48 N.	,, 21,	*m*
U Aquilæ	19 23·4	7 16 S.	,, 22,	0 0 *m*
S Sagittæ	19 51·0	16 20 N.	,, 20,	21 0 *m*
			,, 23,	21 0 *M*
T Vulpeculæ	20 46·8	27 50 N.	,, 22,	1 0 *m*
			,, 22,	3 0 *M*

M signifies maximum ; *m* minimum ; m_2 secondary minimum.

Meteor Showers.

	R.A.	Decl.	
Near γ Andromedæ	26°	42° N.	Swift ; streaks.
,, γ Camelopardalis	55	71 N.	,, ,,
,, π Draconis	290	62 N.	Slow.

THE CONGRESS OF GERMAN NATURALISTS AND PHYSICIANS.

THE sixty-second Congress of German Naturalists and Physicians will be held, as we have already announced, at Heidelberg, from September 18 to 23; and the meeting promises to be one of great interest. Dr. G. Quincke and Dr. W. Kühne, by whom the various necessary arrangements are being made, have issued a programme, and take the opportunity to say that all naturalists, physicians, and students of the natural sciences, who may choose to attend the meeting, will be cordially welcomed. Although by its statutes the Congress consists only of Germans, foreign investigators, by being present and taking part in the proceedings, give much pleasure to their German colleagues.

The three general meetings will be held in the great hall of the Heidelberg Museum on September 18, 20, and 23. To the second of these general meetings, on September 20, a scheme embodying new statutes will be submitted for consideration. This scheme has been worked out by a committee in consequence of resolutions passed at the Congress held last year at Cologne.

According to the old statutes of 1822, still in force, the Congress consists of members and associates, but only the former have the right of voting. Everyone who has written a book on natural science or on medicine is regarded as a member. No one, however, who has merely written an inaugural dissertation can be considered as an author. Admission as associates is open to all who have occupied themselves scientifically with natural science and medicine. The ordinary ticket costs 12 marks; and the same ticket may be obtained for ladies at half the price. In return for an annual subscription of 5 marks, paid in accordance with the decisions of the Cologne Congress last year, the members receive a special member's ticket. The tickets will often have to be shown, so that members and associates ought to have them always ready.

Resolutions can be passed only at a general sitting; and everything is decided by the votes of a majority of the members. Resolutions with regard to scientific theses are not adopted either at the general sittings or in the Sections. The Sections elect their own Presidents, and may, in addition to the Secretary previously appointed, nominate, if necessary, a second or a third Secretary.

In connection with the meeting, there will be an exhibition of scientific apparatus, instruments, and preparations. It will be held in the town gymnastic hall (*Turnhalle*), Grabengasse, 22. Arrangements are being made for this exhibition by a special committee, the president of which is Herr Stadtrath Leimbach, 59 Gaisbergstrasse, Heidelberg, to whom all communications relating to the exhibition should be addressed. The ordinary ticket secures admission to the exhibition, which will be open daily, to members and associates only, from 8 to 11 o'clock a.m. During these hours, explanations will, if desired, be given by exhibitors or their representatives. After 11 o'clock the exhibition will be open to the public, who will have to pay for admission. A catalogue will be provided for members and associates.

The Directors of the Museum and of the Harmonic Society have placed their rooms at the disposal of the Congress; and through the kindness of the civic authorities, and of the Society to which the Museum belongs, it has been arranged that a concert shall be given in the town garden on September 18, and a festival in the Castle grounds on September 20; that the Castle shall be illuminated on the evening of September 23; and that a ball shall be given in the Museum on September 21. Tickets for the dinner in the great hall of the Museum, on September 19, will be issued at the Reception Room on Tuesday and Wednesday, September 17 and 18. The Reception Room and Inquiry Office will be on the ground floor of the Bayrischer Hof, 2 Rohrbacher Strasse, near the railway station.

Applications for lodgings will be received by Herr Rathschreiber Webel (Rathhaus, Heidelberg), Secretary of the Lodgings Committee. A representative of this Committee will be present in the Reception Room.

A daily Bulletin will be issued during the sitting of the Congress. Every morning it will be found in the Reception Room, with a list of members and associates; also with the orders of the day in the Sections, &c. Reports of papers can only be printed afterwards in the scientific part of the Bulletin. Papers which are intended for publication must be written plainly, and handed in not later than October 8.

A post and telegraph office will be open in the ground floor of the University from 8 a.m. to 8 p.m., and a room will be set apart for the writing of letters. Dr. Quincke and Dr. Kühne have not been able to induce the railway companies to issue tickets at a reduced price.

On Sunday, September 22, the following excursions will be made:—

(1) Through the Valley of the Neckar to Neckarsteinach, Hirschhorn, Eberbach, Ernstthal.

(2) By the Bergstrasse to Weinheim, Bensheim, Auerbach, Zwingenberg, Jugenheim.

(3) In the Palatinate, to Speyer, Neustadt, Annweiler, Dürkheim.

(4) To Mannheim, for the examination of the collections there, and for a visit to the opera.

All members and associates (even those who may already have their tickets) are requested to write their names on the list in the Reception Room, and at the same time to give their cards, with name, titles, and place of residence.

The following is the general order of the day:—

Tuesday, September 17: 9 a.m., opening of the Exhibition; 8 p.m., friendly meeting in the Museum.

Wednesday, the 18th: 9 a.m., first general meeting in the great hall of the Museum. (1) Opening of the Congress: Speeches. (2) Lecture by Geh. Rath von Meyer (Göttingen-Heidelberg), on "Chemical Problems of the Present Day." (3) Lecture by Dr. G. H. Otto Volger (Frankfort), on the "Life and Achievements of Dr. K. Schimper."

Midday: Assembling and formation of the Sections.

Afternoon: Sittings of the Sections.

7 p.m.: Concert in the Town Garden.

Thursday, the 19th: Sittings of the Sections; 5 p.m., dinner in the great hall of the Museum.

Friday, the 20th: 9 a.m., second general meeting in the great hall of the Museum. (1) Lecture by Prof. Hertz (Bonn), on "The Relations between Light and Electricity." (2) Consideration of the scheme of new statutes, under the presidency of Dr. Virchow, as Chairman of the Committee by which the scheme was drawn up. (3) Election (*a*) of the new Committee, (*b*) of the next place of meeting, (*c*) of the business managers of the next meeting.

Afternoon: Sittings of the Sections.

6.30 p.m.: Festival at the Castle.

Saturday, the 21st: Sittings of the Sections. 7.30 p.m., ball in the Museum.

Sunday, the 22nd: Excursions in the neighbourhood.

Monday, the 23rd: 9 a.m., third general meeting in the great hall of the Museum. (1) Lecture by Prof. Th. Puschmann (Vienna), on "The Significance of History for Medicine and the Natural Sciences." (2) Lecture by Prof. Brieger (Berlin), on "Bacteria."

Afternoon: Sittings of the Sections.

7.30 p.m.: Illumination of the Castle.

We append a list of the Sections:—(1) Mathematics and Astronomy; (2) Physics; (3) Chemistry; (4) Botany; (5) Zoology; (6) Entomology; (7) Mineralogy and Geology; (8) Ethnology and Anthropology; (9) Anatomy; (10) Physiology; (11) General Pathology and Pathological Anatomy; (12) Pharmacology; (13) Pharmacy and Pharmacognosis; (14) Medicine; (15) Surgery; (16) Gynæcology; (17) Children's Diseases; (18) Neurology and Pyschiatry; (19) Diseases of the Eye; (20) Diseases of the Ear; (21) Laryngology and Rhinology; (22) Dermatology and Syphilis; (23) Hygiene; (24) Medical Jurisprudence; (25) Medical Geography; (26) Military Sanitation; (27) Dentistry; (28) Veterinary Medicine; (29) Agricultural Chemistry; (30) Mathematics and the Natural Sciences in Relation to Education; (31) Geography; (32) Philosophical Instruments.

THE PROGRESS OF SCIENCE AS EXEMPLIFIED IN THE ART OF WEIGHING AND MEASURING.[1]

TWO centuries ago the world was just beginning to awaken from an intellectual lethargy which had lasted a thousand years. During all that time the children had lived as their parents before them, the mechanical arts had been at a standstill, and the dicta of Aristotle had been the highest authority in science. But now the night of mediævalism was approaching its end, and the dawn of modern progress was at hand. Galileo had laid the foundation for accurate clocks by discovering the isochronism of the simple pendulum; had proved that under the action of gravity light bodies fall as rapidly as heavy ones; had invented the telescope, and with it discovered the spots on the sun, the mountains on the moon, the satellites of Jupiter, and the so-called triple character of Saturn; and, after rendering himself immortal by his advocacy of the Copernican system, had gone to his grave aged, blind, and full of sorrows. His contemporary, Kepler, had discovered the laws which, while history endures, will associate his name with the theory of planetary motion, and he also had passed away. The first Cassini was still a young man, his son was a little child, and his grandson and great-grandson, all of whom were destined to be directors of the Paris Observatory, were yet unborn. The illustrious Huyghens, the discoverer of Saturn's rings and the father of the undulatory theory of light, was in the zenith of his powers. The ingenious Hooke was a little younger; and Newton, towering above them all, had recently invented fluxions, and on April 28, 1686, had presented his "Principia" to the Royal Society of London, and given the theory of gravitation to the world. Bradley, who discovered nutation and the aberration of light; Franklin, the statesman and philosopher, who first drew the lightning from the clouds; Dollond, the inventor of the achromatic telescope; Euler, the mathematician who was destined to accomplish so much in perfecting algebra, the calculus, and the lunar theory; Laplace, the author of the "Mécanique Céleste"; Rumford, who laid the foundation of the mechanical theory of heat; Dalton, the author of the atomic theory, upon which all chemistry rests; and Bessel, the greatest of modern astronomers—these and others almost as illustrious, whom we cannot even name to-night, were still in the womb of time.

Pure science first felt the effects of the new intellectual life, and it was more than a century later before the arts yielded to its influence. Then came Hargreaves, the inventor of the spinning-jenny; Arkwright, the inventor of the cotton-spinning frame; Watt, who gave us the condensing steam-engine; Jacquard, the inventor of the loom for weaving figured stuffs; Murdock, the originator of gas-lighting; Evans, the inventor of the high-pressure steam-engine; Fulton, the father of steam navigation; Trevithick, who ranks very near Watt and Evans in perfecting the steam-engine; and Stephenson, the father of railroads. If now we add the names of those who have given us the telegraph, to wit: Gauss, the eminent physicist and the greatest mathematician of the present century; Weber, Wheatstone, and Henry—all famous physicists—and Morse, the inventor and engineer; we have before us the demi-gods who have transformed the ancient into the modern world, given us machinery which has multiplied the productive power of the human race many-fold, annihilated time and space, and bestowed upon toiling millions a degree of comfort and luxury which was unknown to kings and emperors of old.

The discoveries and inventions of the last two centuries have so far exceeded all others within historic times that we are amply justified in calling this an age of phenomenal progress, and under the circumstances a little self-glorification is pardonable—perhaps even natural. The weekly and monthly records of scientific events which appear in so many newspapers and magazines are the immediate result of this, and the great increase of ephemeral scientific literature has led multitudes of educated people to believe that such records represent actual progress. The multiplication of bricks facilitates the building of houses, but does not necessarily improve architecture. Similarly, the multiplication of minor investigations improves our knowledge of details, but rarely affects the great philosophic theories upon which science is founded. The importance of human actions is measured by the degree in which they affect human thought, and the only way of permanently affecting scientific thought is by modifying or extending scientific theories. The men who do that are neither numerous nor do they require weekly paragraphs to record their deeds; but their names are honoured by posterity. Even in this golden age the advance of science is not steady, but is made by spasmodic leaps and bounds. Mere scientific brick-making, commonly called progress, is always the order of the day until some genius startles the world by a discovery affecting accepted theories. Then every effort is directed in the new line of thought until it is measurably worked out, and after that brick-making again resumes its place. While the progress in two centuries has been immense, the progress in a week or a month is usually almost *nil*. Optimism has its uses in many departments of human affairs, but science should be cool and dispassionate, having regard only for the truth. To make a trustworthy estimate of the actual state of the whole vast realm of science would be a task beyond the powers of any one man; but perhaps it will not be amiss to spend the time at our disposal this evening in briefly reviewing the recent progress and present condition of the fundamental processes upon which the exact sciences rest—I allude to the methods of weighing and measuring.

Physical science deals with many quantities, but they are all so related to each other that almost every one of them can be expressed in terms of three fundamental units. As several systems of such units are possible, it is important to select the most convenient, and the considerations which guide us in that respect are the following:—

(1) The quantities selected should admit of very accurate comparison with other quantities of the same kind.

(2) Such comparisons should be possible at all times, and in all places.

(3) The processes necessary for making such comparisons should be easy and direct.

(4) The fundamental units should be such as to admit of easy definitions and simple dimensions for the various derived units.

Scientific men have long agreed that these requirements are best fulfilled by adopting as the fundamental units a definite length, a definite mass, and a definite interval of time. Length is an element which can be very accurately measured and copied, but it must be defined by reference to some concrete material standard, as, for example, a bar of metal; and as all substances expand and contract with changes of temperature, it is necessary to state the temperature at which the standard is correct. A standard of mass, consisting of a piece of platinum, quartz, or other material not easily affected by atmospheric influences, probably fulfils the conditions set forth above better than any other kind of magnitude. Its comparison with other bodies of approximately equal mass is effected by weighing, and as that is among the most exact of all laboratory operations, very accurate copies of the standard can be made, and they can be carried from place to place with little risk of injury. Time is also an element which can be measured with extreme precision. The immediate instruments of measurement are clocks and chronometers, but their running is checked by astronomical observations, and the ultimate standard is the rotation of the earth itself.

It is important to note that the use of three fundamental units is simply a matter of convenience and not a theoretical necessity, for the unit of mass might be defined as that which at unit distance would generate in a material point unit velocity in unit time; and thus we should have a perfectly general system of measurement based upon only two fundamental units—namely,

[1] Annual Address of Dr. William Harkness, President of the Philosophical Society of Washington, delivered on December 10, 1887.

those of space and time. Such a system is quite practicable in astronomy, but cannot yet be applied with accuracy to ordinary terrestrial purposes. According to the law of gravitation,

$$\text{Mass} = \text{Acceleration} \times (\text{Distance})^2;$$

and as in the case of the earth we can measure the quantities on the right-hand side of that equation with considerable accuracy, we can satisfactorily determine the earth's mass in terms of the supposed unit. That suffices for the needs of astronomy, but for other scientific and commercial purposes a standard of mass having a magnitude of about a pound is necessary, and as two such masses can be compared with each other from five to ten thousand times more accurately than either of them can be determined in terms of the supposed unit, three fundamental units are preferable to two.

The Chaldeans, Babylonians, Persians, Greeks, and Romans, all seem to have had systems of weights and measures based upon tolerably definite standards, but after the decline of the Roman Empire these standards seem to have been forgotten, and in the beginning of the sixteenth century the human body had so far become the standard of measurement that the units in common use—as, for example, the foot, palm, &c.,—were frequently taken directly from it. The complete table of measures of length was then as follows: the breadth (not the length) of four barley-corns make a digit, or finger-breadth; four digits make a palm (measured across the middle joints of the fingers); four palms are one foot; a foot and a half is a cubit; ten palms, or two feet and a half, are a step; two steps, or five feet, are a pace; ten feet are a perch; one hundred and twenty-five paces are an Italic stadium; eight stadia, or one thousand paces, are an Italic mile; four Italic miles are a German mile; and five Italic miles are a Swiss mile. It was then the practice to furnish standards of length in books by printing in them lines a foot or a palm long, according to the size of the page, and from these and other data it appears that the foot then used on the continent of Europe had a length of about ten English inches.

In England, the first attempts at scientific accuracy in matters of measurement date from the beginning of the seventeenth century, when John Greaves, who must be considered as the earliest of the scientific metrologists, directed attention to the difference between the Roman and English foot by tolerably accurate determinations of the former, and also attempted the investigation of the Roman weights. He was followed by Dr. Edward Bernard, who wrote a treatise on ancient weights and measures about 1685, and towards the end of the century the measurements of the length of a degree by Picard and J. D. Cassini awakened the attention of the French to the importance of rigorously exact standards. In considering the progress of science with respect to standards of length, we may safely confine our inquiries to the English yard and the French toise and metre, for during the last two hundred years they have been almost the only standards adopted in scientific operations.

The English measures of length have come down from the Saxons, but the oldest standards now existing are the Exchequer yards of Henry VII. (1490) and Elizabeth (1588). These are both brass-end measures, the former being an octagonal rod about half an inch in diameter, very coarsely made, and as rudely divided into inches on the right-hand end and into sixteenths of a yard on the left-hand end; the latter a square rod with sides about half an inch wide, also divided into sixteenths of a yard, and provided with a brass bed having end-pieces between which the yard fits. One end of the bed is divided into inches and half-inches. Francis Baily, who saw this Elizabethan standard in 1836, speaks of it as "this curious instrument, of which it is impossible, at the present day, to speak too much in derision or contempt. A common kitchen poker, filed at the ends in the rudest manner by the most bungling workman, would make as good a standard. It has been broken asunder; and the two pieces have been dove-tailed together: but so badly that the joint is nearly as loose as that of a pair of tongs. The date of this fracture I could not ascertain, it having occurred beyond the memory or knowledge of any of the officers at the Exchequer. And yet, till within the last ten years, to the disgrace of this country, copies of this measure have been circulated all over Europe and America, with a parchment document accompanying them (charged with a stamp that costs £3 10*s.*, exclusive of official fees), certifying that they are true copies of the English *standard*."

In the year 1742 certain members of the Royal Society of London, and of the Royal Academy of Sciences of Paris, proposed that, in order to facilitate a comparison of the scientific operations carried on in the two countries, accurate standards of the measures and weights of both should be prepared and preserved in the archives of each of these Societies. This proposition having been approved, Mr. George Graham, at the instance of the Royal Society, had two substantial brass rods made, upon which he laid off, with the greatest care, the length of 3 English feet from the standard yard kept at the Tower of London. These two rods, together with a set of troy weights, were then sent over to the Paris Academy, which body, in like manner, had the measure of a French half-toise set off upon the rods, and keeping one, as previously agreed, returned the other, together with a standard weight of two marcs, to the Royal Society. In 1835, Baily declared this copy of the half-toise to be of little value because the original *toise-étalon* was of iron, and the standard temperature in France differed from that in England. In his opinion the French should have sent over an iron half-toise in exchange for the English brass yard; but this criticism loses much of its force when it is remembered that in 1742 neither England nor France had fixed upon a temperature at which their standards were to be regarded as of the true length. On the return of the rod from Paris, Mr. Graham caused Jonathan Sisson to divide the English yard and the French half-toise each into three equal parts, after which the rod was deposited in the archives of the Royal Society, where it still remains. Objection having been made that the original and legal standard yard of England was not the one at the Tower, but the Elizabethan standard at the Exchequer, the Royal Society requested Mr. Graham to compare his newly-made scale with the latter standard, and on Friday, April 22, 1743, he did so in the presence of a Committee of seven members of the Royal Society. In the following week the same gentlemen compared the Royal Society's scale with the standards at Guildhall and the Tower, and also with the standard of the Clockmakers' Company. These comparisons having shown that the copy of the Tower yard upon the Royal Society's scale was about 0·0075 of an inch longer than the standard at the Exchequer, Mr. Graham inscribed upon the Royal Society's scale a copy of the latter standard also, marking it with the letters Exch., to distinguish it from the former, which was marked E. (English), and from the half-toise which was marked F. (French).

In the year 1758 the House of Commons appointed a Committee to inquire into the *original* standards of weights and measures of England; and, under instructions from that Committee, the celebrated instrument-maker, John Bird, prepared two brass rods, respecting which the Committee speak as follows in their Report: "And having those rods, together with that of the Royal Society, laid in the same place, at the receipt of the Exchequer, all night with the standards of length kept there, to prevent the variation which the difference of air might make upon them, they the next morning compared them all, and, by the means of beam compasses brought by Mr. Bird, found them to agree as near as it was possible." One of these rods was arranged as a matrix for testing end-measures, and the other was a line measure which the Committee recommended should be made the legal standard of England, and which has since been known as Bird's standard of 1758. Respecting the statement that after lying together all night the rods were *all* found to agree as near as it was possible, Baily says: "This is somewhat remarkable, and requires further explanation, which unfortunately cannot now be accurately obtained. For it is notorious that the measure of the yard of the Royal Society's scale differs very considerably from the standard yard at the Exchequer. . . . Owing to this singular confusion of the lengths of the measures, which does not appear to have been unravelled by any subsequent Committee, it has happened that the Imperial standard yard . . . has been assumed nearly 1 ÷ 140 of an inch longer than the ancient measure of the kingdom." There is little difficulty in surmising what Bird did. The Exchequer standard consisted of a rod and its matrix. The Royal Society's Committee assumed the rod to be the true standard of 36 inches, and upon that assumption Graham's measurements gave for the length of the matrix 36·0102 inches, and for the length of the Royal Society's yard 36·0075 inches. The Parliamentary Committee of 1758 probably assumed the standard to consist of the rod and matrix together, which seems the better view; and by laying the rod in its matrix, and measuring to the joint between them, Bird would have got a length of about 36·0051 inches. The mean between that and 36·0075 would be 36·0063, which differs very little from the length of Bird's standard resulting from Sir George Shuckburgh's measurements. Thus the Committee's statement is justified, and there has been no falsification of the ancient standards.

On December 1, 1758, Parliament created another Committee on Weights and Measures, which, in April 1759, repeated the recommendation that Bird's standard of 1758 should be legalized, and further recommended that a copy of it should be made and deposited in some public office, to be used only on special occasions. The copy was made by Bird in 1760, but, owing to circumstances entirely unconnected with the subject, no legislation followed for sixty-four years.

The Royal Commission appointed during the reign of George III. to consider the subject of weights and measures, made its first Report on June 24, 1819, and therein recommended the adoption of the standard of length which had been used by General Roy in measuring the base on Hounslow Heath; but in a second Report, made July 13, 1820, they wrote:—"We . . . have examined, since our last Report, the relation of the best authenticated standards of length at present in existence, to the instruments employed for measuring the base on Hounslow Heath, and in the late trigonometrical operations; but we have very unexpectedly discovered that an error has been committed in the construction of some of these instruments. We are therefore obliged to recur to the originals which they were intended to represent, and we have found reason to prefer the Parliamentary standard executed by Bird in 1760, which we had not before received, both as being laid down in the most accurate manner, and as the best agreeing with the most extensive comparisons which have been hitherto executed by various observers, and circulated through Europe; and in particular with the scale employed by the late Sir George Shuckburgh."

Accordingly, when in 1824 Parliament at length took action, Bird's standard of 1760 was adopted instead of that of 1758. The former being a copy of a copy, its selection as a national standard of length seems so singular that the circumstances which brought about that result should scarcely be passed over in silence. Bird had a very accurate brass scale 90 inches long, which he used in all his dividing operations, whether upon circles or straight lines, and which Dr. Maskelyne said was 0·001 of an inch shorter on 3 feet than Graham's Royal Society yard E. In the year 1792, or 1793, the celebrated Edward Troughton made for himself a 5-foot scale, which conformed to Bird's, and which he afterwards used in laying down the divisions of the various instruments that passed through his hands. This was the original of all the standard scales he ever made, and at the beginning of the present century he believed these copies, which wete made by the aid of micrometer microscopes, to be so exact that no variations could possibly be detected in them, either from the original or from each other. Among the earliest of the scales so made by Troughton was the one used by Sir George Shuckburgh in 1796–98 in his important scientific operations for the improvement of the standards. Subsequently, the length of the metre was determined by comparison with this scale and with the supposed facsimile of it made by Troughton for Prof. Pictet, of Geneva; and thus it happened that on the continent of Europe all measures were converted into English units by a reference to Sir George Shuckburgh's scale. The Royal Commission of 1819 believed Bird's standard of 1760 to be identical with Shuckburgh's scale, and they legalized it rather than the standard of 1758, in order to avoid disturbing the value of the English yard, which was then generally accepted for scientific purposes.

There are yet four other scales of importance in the history of English standards—namely, the brass 5-foot scale made for Sir George Shuckburgh by Troughton in 1796; two iron standard yards, marked 1A and 2A, made for the English Ordnance Survey Department by Messrs. Troughton and Simms in 1826–27; and the Royal Society's standard yard, constructed by Mr. George Dollond, under the direction of Capt. Henry Kater, in 1831.

Bearing in mind the preceding history, the genesis of the present English standard yard may be thus summarized. In 1742, Graham transferred to a bar made for the Royal Society a length which he intended should be that of the Tower yard, but which was really intermediate between the Exchequer standard yard of Elizabeth and its matrix. That length he marked with the letter E, and, although destitute of legal authority, it was immediately accepted as the scientific standard, and was copied by the famous instrument-makers of the time with all the accuracy then attainable. Thus it is in fact the prototype to which all the accurate scales made in England between 1742 and 1850 can be traced. Bird's standard of 1758 was compared with the Exchequer standard and with the Royal Society's yard E., and was of a length between the two. Bird's standard of 1760, legalized as the Imperial standard, in June 1824, was copied from his standard of 1758. After becoming the Imperial standard, Bird's standard of 1760 was compared with Sir George Shuckburgh's scale by Capt. Kater, in 1830, and by Mr. Francis Baily, in 1834; with the Ordnance yards 1A and 2A, in 1834, by Lieut. Murphy, R.E., Lieut. Johnson, R.N., and Messrs. F. Baily and Donkin; and with Kater's Royal Society yard by Capt. Kater, in 1831. On October 16, 1834, the Imperial standard (Bird's standard of 1760) was destroyed by the burning of the Houses of Parliament, in which it was lodged; and very soon thereafter the Lords of the Treasury took measures to recover its length. Preliminary inquiries were begun on May 11, 1838; and on June 20, 1843, they resulted in the appointment of a Commission to superintend the construction of new Parliamentary standards of length and weight, among whose members the Astronomer-Royal (now Sir George B. Airy), Messrs. F. Baily, R. Sheepshanks, and Prof. W. H. Miller, were prominent. The laborious investigations and experiments carried out by that Commission cannot be described here, but it will suffice to say that for determining the true length of the new standard Mr. Sheepshanks employed a provisional yard, marked upon a new brass bar designated "Brass 2," which he compared as accurately as possible with Sir George Shuckburgh's scale, the two Ordnance yards, and Kater's Royal Society yard. The results in terms of the lost Imperial standard were as follows:—

Brass bar 2 = 36·000084 from comparison with Shuckburgh's scale, 0–36 in.
36·000280 ,, ,, ,, ,, 10–46 in.
36·000303 from comparison with the Ordnance yard, 1A.
36·000275 ,, ,, ,, ,, 2A.
36·000229 from Capt. Kater's Royal Society yard.

Mean = 36·000234

Respecting this mean, Mr. Sheepshanks wrote:—"This should be pretty near the truth; but I prefer 36·00025, if in such a matter such a difference be worth notice. I propose, therefore, in constructing the new standard to assume that—

Brass bar 2 = 36·00025 inches of lost Imperial standard at 62° F."

And upon that bar is the standard now in use was constructed.

Turning now to the French standards of length, it is known that the ancient *toise de maçons* of Paris was probably the toise of Charlemagne (A.D. 742 to 814), or at least of some Emperor Charles, and that its *étalon* was situated in the courtyard of the old Châtelet, on the outside of one of the pillars of the building. It still existed in 1714, but entirely falsified by the bending of the upper part of the pillar. In 1668 the ancient toise of the masons was reformed by shortening it five lines; but whether this reformation was an arbitrary change, or merely a change to remedy the effects of long use and restore the *étalon* to conformity with some more carefully-preserved standard, is not quite clear. These old *étalons* were iron bars having their two ends turned up at right angles so as to form *talons*, and the standardizing of end measures was effected by fitting them between the *talons*. Being placed on the outside of some public building, they were exposed to wear from constant use, to rust, and even to intentional injury by malicious persons. Under such conditions every *étalon* would, sooner or later, become too long and require shortening.

Respecting the ancient toise of the masons there are two contradictory stories. On December 1, 1714, La Hire showed to the French Academy what he characterized as "a very ancient instrument of mathematics, which has been made by one of our most accomplished workmen with very great care, where the foot is marked, and which has served to re-establish the toise of the Châtelet, as I have been informed by our old mathematicians." Forty-four years later, on July 29, 1758, La Condamine stated to the Academy that "We know only by tradition that to adjust the length of the new standard, the width of the arcade or interior gate of the grand pavilion, which served as an entrance to the old Louvre, on the side of the rue Fromenteau, was used. This opening, according to the plan, should have been 12 feet wide. Half of it was taken to fix the length of the new toise, which thus became five lines shorter than the old one." Of these two contradictory statements that of La Hire seems altogether most trustworthy, and the ordinary rules of evidence indicate that it should be accepted to the exclusion of the other.

In 1668 the *étalon* of the new toise, since known as the *toise-étalon du Châtelet*, was fixed against the wall at the foot of the staircase of the *grand Châtelet de Paris*—by whom or at what season of the year is not known. Strange as it now seems, this standard—very roughly made, exposed in a public place for use or abuse by everybody, liable to rust, and certain to be falsified by constant wear—was actually used for adjusting the toise of Picard, that of Cassini, the toise of Peru and of the North, that of La Caille, that of Mairan; in short, all the toises employed by the French in their geodetic operations during the seventeenth and eighteenth centuries. The lack of any other recognized standard made the use of this one imperative, but the French Academicians were well aware of its defects, and took precautions to guard against them.

The first toise copied from the *étalon* of the Châtelet for scientific purposes was that used by Picard in his measurement of a degree of the meridian between Paris and Amiens. It was made about the year 1668, and would doubtless have become the scientific standard of France had it not unfortunately disappeared before the degree measurements of the eighteenth century were begun. The second toise copied from the *étalon* of the Châtelet for scientific purposes was that used by Messrs. Godin, Bouguer, and La Condamine for measuring the base of their arc of the meridian in Peru. This toise, since known as the *toise du Pérou*, was made by the artist Langlois under the immediate direction of Godin in 1735, and is still preserved at the Paris Observatory. It is a rectangular bar of polished wrought iron, having a breadth of 1·58 English inches and a thickness of 0·30 of an inch. All the other toises used by the Academy in the eighteenth century were compared with it, and, ultimately, it was made the legal standard of France by an order of Louis XV., dated May 16, 1766. As the toise of Peru is the oldest authentic copy of the toise of the Châtelet, the effect of this order was simply to perpetuate the earliest known state of that ancient standard.

The metric system originated from a motion made by Talleyrand in the National Assembly of France, in 1790, referring the question of the formation of an improved system of weights and measures, based upon a natural constant, to the French Academy of Sciences; and the preliminary work was intrusted to five of the most eminent members of that Academy—namely, Lagrange, Laplace, Borda, Monge, and Condorcet. On March 19, 1791, these gentlemen, together with Lalande, presented to the Academy a Report containing the complete scheme of the metric system. In pursuance of the recommendations in that Report, the law of March 26, 1791, was enacted for the construction of the new system, and the Academy of Sciences was charged with the direction of the necessary operations. Those requisite for the construction of a standard of length were:—

(1) The determination of the difference of latitude between Dunkirk and Barcelona.

(2) The remeasurement of the ancient bases which had served for the measurement of a degree at the latitude of Paris, and for making the map of France.

(3) The verification by new observations of the series of triangles employed for measuring the meridian, and the prolongation of them as far as Barcelona.

This work was intrusted to Méchain and Delambre, who carried it on during the seven years from 1791 to 1798, notwithstanding many great difficulties and dangers. The unit of length adopted in their operations was the toise of Peru, and from the arc of 9° 40′ 45″ actually measured, they inferred the length of an arc of the meridian extending from the equator to the Pole to be 5,130,740 toises. As the metre was to be 1/10,000,000 of that distance, its length was made 0·5130740 of a toise, or, in the language of the Committee, 443·296 lines of the toise of Peru at a temperature of 13° Réaumur (16¼° C. or 61¼° F.).

Before attempting to estimate how accurately the standards we have been considering were intercompared, it will be well to describe briefly the methods by which the comparisons were effected. In 1742, Graham used the only instruments then known for the purpose—namely, very exact beam compasses of various kinds, one having parallel jaws for taking the lengths of the standard rods, another with rounded ends for taking the lengths of the hollow beds, and still another having fine points in the usual manner. The jaws, or points, of all these instruments were movable by micrometer screws having heads divided to show the eight-hundredth part of an inch directly, and the tenth of that quantity by estimation; but Mr. Graham did not consider that the measurements could be depended upon to a greater accuracy than 1/1600 of an inch.

Troughton is generally regarded as the author of the application of micrometer microscopes to the comparison of standards of length, but the earliest record of their use for that purpose is by Sir George Shuckburgh in his work for the improvement of the standards of weight and measure in 1796-98. Since then their use has been general; first, because they are more accurate than beam compasses, and, second, because they avoid the injury to standard scales which necessarily results from placing the points of beam compasses upon their graduations. As the objective of the microscope forms a magnified image of the standard, upon which the micrometer wires are set by the aid of the eye-piece, it is evident that in order to reduce the effect of imperfections in the micrometer, the objective should have the largest practicable magnifying power. To show the progress in that direction, the optical constants of the microscopes, by means of which some of the most important standards have been compared, are given in the accompanying table.

Date.	Observer.	Power of microscope.	Magnifying power of objective.	Equivalent focus of eye-piece.	Value of one revolution of micrometer screw.
				Inches.	Inches.
1797	Sir Geo. Shuckburgh	14	1·7	1·50	0·01000
1817	Capt. Henry Kater	18	(2·3)	—	·00428
1834	Francis Baily	27	(2·0)	¾	·00500
1834	Lieut. Murphy, R.E.	—	(2·0)	—	·00500
1850	R. Sheepshanks	—	(2·8)	—	·00358
1864	Gen. A. R. Clarke, R.E. ...	60	4·0	0·67	·00287
1880	Prof. W. A. Rogers, 1-in. obj.	—	(12·7)	—	·00079
	,, ,, ½-in. obj.	—	(28·6)	—	·00035
	,, ,, ¼-in. obj.	—	(52·7)	—	·00019
1883	International Bureau	90	7·5	0·83	0·00394

NOTE.—The magnifying power of Sir Geo. Shuckburgh's microscope seems to be referred to a distance of 12 inches for distinct vision. The powers inclosed in parentheses are estimated upon the assumption that the respective micrometer screws had 100 threads per inch.

In the Memoirs of the French Academy nothing is said respecting the method adopted by the Academicians for comparing their various toises; but in his "Astronomy," Lalande states that the comparisons were effected partly by beam compasses, and partly by superposing the toises upon each other and examining their ends, both by touch and with magnifying glasses, they being all end standards. For the definitive adjustment of the length of their metres, which were also end standards, the French Metric Commission used a lever comparator by Lenoir.

In 1742, Graham used beam compasses, which he considered trustworthy to 0·00062 of an inch, in comparing standards of length; but at that time the French Academicians made their comparisons of toises only to one-twentieth or one-thirtieth of a line, say 0·00300 of an inch, and it was not until 1758 that La Condamine declared they should be compared to 0·01 of a line, or 0·00089 of an English inch, "if our senses, aided by the most perfect instruments, can attain to that." Half a century later, ten times that accuracy was attained by the lever comparator of Lenoir, which was regarded as trustworthy to 0·000077 of an inch ("Base du Système Métrique," t. iii. pp. 447–62).

The heads of micrometer microscopes are usually divided into 100 equal parts, and if we regard one of these parts as the least reading of a microscope, then in 1797 Sir George Shuckburgh's microscopes read to 1/10,000 of an inch; and the least reading of microscopes made since that date has varied from 1/20,000 to 1/35,000 of an inch. A few investigators, among whom may be mentioned Prof. W. A. Rogers, of Colby University, have made the least reading of their microscopes as small as 1/90,000 of an inch, but it is doubtful if there is any advantage in so doing. At the present day the errors committed in comparing standards arise, not from lack of power in the microscopes, but from the difficulty of determining sufficiently exactly the temperature of the standard bars, and the effect of flexure upon the position of their graduations. In order to ascertain the length of a 3-foot standard with an error not exceeding 0·000020 of an inch, its temperature must be known to 0°·06 F. if it is of brass, or to 0°·09 F. if it is of iron. To get thermometers that will indicate their own temperature to that degree of accuracy is by no means easy, but to determine the temperature of a bar from their readings is far more difficult. Again, we imagine the length of our standards to follow their temperature rigorously, but what proof is there that such is the case? If we determine the freezing point of an old thermometer, then raise it to the temperature of boiling water, and immediately thereafter again determine its freezing-point, we invariably find that the freezing-point has fallen a little; and we explain this by saying that the glass has taken a set, from which it requires time to recover. Is it not probable that an effect similar in kind, although less in degree, occurs in all solids when their temperature is varying? When we look at the highly polished terminals of an end-standard, we are apt to regard them as mathematical surfaces, separated by an interval which is perfectly definite, and which could be measured with infinite precision if we only had the necessary instrumental appliances; but is that a correct view? The atomic theory answers emphatically, No. According to it, all matter consists of atoms, or molecules, of a perfectly definite size, and with definite intervals between them; but even if that is denied, the evidence is now overwhelming that matter is not homogeneous, but possesses a grain of some kind, regularly repeated at intervals which cannot be greater than 1/2,000,000 nor less than 1/400,000,000 of an inch. Accordingly we must picture our standard bar as a conglomeration of grains of some kind or other, having magnitudes of the order specified, and all in ceaseless motion, the amplitude of which depends upon the temperature of the bar. To our mental vision the polished terminals are therefore like the surface of a pot of boiling water, and we recognize that there must be a limit to the accuracy with which the interval between them can be measured. As a basis for estimating how near this limit we have approached, it will suffice to say that for fifty years past it has been customary to state comparisons of standards of length to 1/100,000, of an inch. Nevertheless, most authorities agree that, although 1/100,000 of an inch can be distinguished in the comparators, 1/25,000 of an inch is about the limit of accuracy attainable in comparing standards. Possibly such a limit may be reached under the most favourable circumstances, but in the case of the yard and the metre, which are standard at different temperatures, the following values of the metre by observers of the highest repute render it doubtful if anything like that accuracy has yet been attained:—

1818	Capt. Henry Kater	39·37079 inches.
1866	General A. R. Clarke ...	39·37043 ,,
1883	Prof. Wm. A. Rogers ...	39·37027 ,,
1885	General C. B. Comstock ...	39·36985 ,,

The earliest standard of English weight of which we have any very definite knowledge is the Mint pound of the Tower of London. It weighed 5400 troy grains, and the coinage was regulated by it up to the year 1527, when it was abolished in favour of the troy pound of 5760 grains. Contemporaneously with the Tower pound there was also the merchant's pound, whose exact weight is now involved in so much doubt that it is impossible to decide whether it consisted of 6750 or of 7200 grains. The Tower pound and the troy pound were used for weighing only gold, silver, and drugs, while all other commodities were weighed by the merchant's pound until the thirteenth or fourteenth century, and after that by the avoirdupois pound. It is not certainly known when the troy and avoirdupois pounds were introduced into England, and there is no evidence of any relation between them when they first became standards. The present avoirdupois pound can be clearly proved to be of similar weight to the standard avoirdupois pound of Edward III. (A.D. 1327–77), and there is good reason for believing that no substantial change has occurred either in its weight or in that of the troy pound since their respective establishment as standards in England.

The oldest standard weights now existing in the English archives date from the reign of Queen Elizabeth, and consist of a set of bell-shaped avoirdupois weights of 56, 28, and 14 pounds, made in 1582, and 7, 4, 2, and 1 pounds made in 1588; a set of flat circular avoirdupois weights of 8, 4, 2, and 1 pounds, and 8, 4, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{16}$ ounces, made in 1588; and a set of cup-shaped troy weights, fitting one within the other, of 256, 128, 64, 32, 16, 8, 4, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ (hollow) and $\frac{1}{8}$ (solid) ounces, also made in 1588. All these standards were constructed by order of Queen Elizabeth, under the direction of a jury composed of eighteen merchants and eleven goldsmiths of London, the avoirdupois weights being adjusted according to an ancient standard of 56 pounds, remaining in the Exchequer from the time of Edward III.; and the troy weight being adjusted according to the ancient standard in Goldsmiths' Hall.

In view of the fact that the weight mentioned in all the old Acts of Parliament from the time of Edward I. (A.D. 1274–1307) is universally admitted to be troy weight, the Parliamentary Committee of 1758, appointed to inquire into the original standards of weights and measures in England, recommended that the troy pound should be made the unit or standard by which the avoirdupois and other weights should be regulated; and by their order three several troy pounds of soft gun-metal were very carefully adjusted under the direction of Mr. Joseph Harris, who was then Assay Master of the Mint. To ascertain the proper mass for these pounds, the Committee caused Messrs. Harris and Gregory, of the Mint, to perform the following operations in their presence:—

(1) In the before-mentioned set of troy weights, made in 1588, which were then the Exchequer standard, each weight, from that of 4 ounces up to that of 256 ounces was compared successively with the sum of all the smaller weights; and by a process for which no valid reason can be assigned, it was concluded from these weighings that the troy pound composed of the 8 and 4 ounce weights was $1\frac{1}{2}$ grains too light.

(2) The aforesaid 8 and 4 ounce weights of the Exchequer were compared with five other authoritative troy pounds, four of which belonged to the Mint and one to Mr. Freeman, who, like his father before him, was scale-maker to the Mint, and from the mean of these weighings it appeared that the sum of the Exchequer 8 and 4 ounce weights was 1 grain too light.

The Committee adopted the mean between the latter result and that which they had deduced from the Exchequer weights alone, and accordingly Mr. Harris made each of his three troy pounds $1\frac{1}{4}$ grains heavier than the sum of the Exchequer 8 and 4 ounce weights; but sixty-six years were destined to elapse before Parliament took action respecting them.

The Commissioners appointed in 1818 to establish a more uniform system of weights and measures repeated the recommendations of the Committee of 1758, and as the avoirdupois pound which had long been used, although not legalized by any Act of the Legislature, was very nearly 7000 troy grains, they recommended that 7000 such troy grains be declared to constitute a pound avoirdupois. These recommendations were embodied in the Act of Parliament of June 17, 1824, and thus one of the troy pounds made in 1758 became the Imperial standard. That standard, like Bird's standard yard, was deposited in the Houses of Parliament, and was burned up with them in October 1834.

The present English standard pound was made in 1844–46 by Prof. W. H. Miller, who was one of the members of the Commission appointed in 1843 to superintend the construction of the new Parliamentary standards of length and weight destined to replace those destroyed in 1834. A number of weights had been very accurately compared with the lost standard; namely, in 1824 or 1825, by Capt. Kater, 5 troy pounds of gun-metal, destined respectively for the use of the Exchequer, the Royal Mint, and the cities of London, Edinburgh, and Dublin; and in 1829, by Capt. von Nehus, two troy pounds of brass and one of platinum, all in the custody of Prof. Schumacher, and a platinum troy pound belonging to the Royal Society. The first step for recovering the mass of the lost standard was manifestly to compare these weights among themselves, and upon so doing it was found that for the brass and gun-metal weights the discrepancies between the weighings made in 1824 and 1844 amounted to 0·0226 of a grain, while for the two platinum weights the discrepancies between the weighings made in 1829 and 1845 was only 0·00019 of a grain. With a single exception, all the *new* brass or gun-metal weights had become heavier since their first comparison with the lost standard, the change being probably due to oxidation of their surfaces, and on that account the new standard was made to depend solely upon the two platinum weights. For convenience of reference these weights were designated respectively S*p* (Schumacher's platinum, and RS (Royal Society). A provisional platinum troy pound, T, intermediate in mass between S*p* and RS was next prepared, and from 286 comparisons made in January, February, July, and August, 1845, it was found that in a vacuum

$$T = Sp + 0·00105 \text{ grain},$$

while from 122 comparisons made in January, July, and August, 1845,

$$T = RS - 0{\cdot}00429 \text{ grain.}$$

By combining these values with the results of the weighings made in 1824–29—namely,

$$Sp = U - 0{\cdot}52956 \text{ grain,}$$
$$RS = U - 0{\cdot}52441 \text{ grain,}$$

where U designates the lost standard—the comparisons with S*p* gave

$$T = U - 0{\cdot}52851 \text{ grain,}$$

while those with RS gave

$$T = U - 0{\cdot}52870 \text{ grain.}$$

To the first of these expressions double weight was assigned, because the comparisons of T and U with S*p* were about twice as numerous as those with RS. The resulting mean was therefore

$$T = U - 0{\cdot}52857 \text{ grain} = 5759{\cdot}47143 \text{ grains,}$$

and from that value of T the new standard avoirdupois pound of 7000 grains was constructed.

From some time in the fifteenth century until the adoption of the metric system in August 1793, the system of weights employed in France was the *poids de marc*, having for its ultimate standard the *pile de Charlemagne*, which was then kept in the Mint, and is now deposited in the Conservatoire des Arts et Métiers. The table of this weight was

72 grains	= 1 gros	=	72	grains.
8 gros	= 1 once	=	576	,,
8 onces	= 1 marc	=	4608	,,
2 marcs	= 1 livre	=	9216	,,

The origin of the *pile de Charlemagne* is not certainly known, but it is thought to have been made by direction of King John (A.D. 1350–64). It consists of a set of brass cup-weights, fitting one within the other, and the whole weighing 50 marcs. The nominal and actual weights of the several pieces are as follows:—

	Marcs.		Grains.
Boîte de 20 marcs ...	20	+	1·4
Pièce de 14 ,, ...	14	+	4·5
,, de 8 ,, ...	8	–	0·4
,, de 4 ,, ...	4	–	2·1
,, de 2 ,, ...	2	–	1·0
,, de 1 ,, ...	1	–	0·7
Marc divisé	1	–	1·7
	50	±	0·0

In determining the relation of the *poids de marc* to the metric weights, the Committee for the Construction of the Kilogramme regarded the entire *pile de Charlemagne* as a standard of 50 marcs, and considered the individual pieces as subject to the corrections stated. On that basis they found

1 kilogramme = 18,827·15 French grains;[1]

and as a kilogramme is equal to 15,432·34874 English troy grains, we have

1 livre, poids de marc = 7554·22 troy grains.
= 489·505 grammes.

The metric standard of weight, called a kilogramme, was constructed under the direction of the French Academy of Sciences simultaneously with the metre, the work being done principally by Lefèvre-Gineau and Borda. It was intended that the kilogramme should have the same mass as a cubic decimetre of pure water at maximum density, and the experimental determination of that mass was made by finding the difference of weight in air and in water of a hollow brass cylinder whose exterior dimensions at a temperature of 17°·6 C. were: height = 2·437672 decimetres, diameter = 2·428368 decimetres, volume = 11·2900054 cubic decimetres. The difference of weight in question was first measured in terms of certain brass weights, by the aid of which the platinum kilogramme of the Archives was subsequently constructed, special care being taken to apply the corrections necessary to reduce all the weighings to what they would have been if made in a vacuum ("Base du Système Métrique," t. iii. pp. 574–75).

[1] "Base du Système Métrique," t. iii p. 638.

The best results hitherto obtained for the weight of a cubic decimetre of water, expressed in terms of the kilogramme of the Archives, are as follows[1]:—

Date.	Country.	Observer.	Weight of a cubic decimetre of water at 4° C.
			Grammes.
1795	France ...	Lefèvre-Gineau	1000·000
1797 } 1821 }	England ...	Shuckburgh and Kater	1000·480
1825	Sweden ...	Berzelius, Svanberg, and Akermann	1000·296
1830	Austria ...	Stampfer	999·653
1841	Russia ...	Kupffer	999·989
		Mean	1000·084

These results show the extreme difficulty of determining the exact mass of a given volume of water. The discordance between the different observers amounts to more than one part in a thousand, while good weighings are exact to one part in eight or ten millions. Without doubt two weights can be compared at least a thousand times more accurately than either of them can be reproduced by weighing a specified volume of water, and for that reason the kilogramme, like the English pound, can now be regarded only as an arbitrary standard of which copies must be taken by direct comparison. As already stated, the kilogramme is equivalent to 15,432·34874 English troy grains, or about 2 pounds 3 ounces avoirdupois.

In consequence of the circumstance that the mass of a body is not affected either by temperature or flexure, weighing is an easier process than measuring; but in order to obtain precise results many precautions are necessary. Imagine a balance with a block of wood tied to its right-hand pan and accurately counterpoised by lead weights in its left-hand pan. If, with things so arranged, the balance were immersed in water, the equilibrium would be instantly destroyed, and to restore it all the weights would have to be removed from the left-hand pan, and some of them would have to be placed in the right-hand pan to overcome the buoyancy of the wood. The atmosphere behaves precisely as the water does, and although its effect is minute enough to be neglected in ordinary business affairs, it must be taken into account when scientific accuracy is desired. To that end the weighing must either be made in a vacuum, or the difference of the buoyant effect of the air upon the substances in the two pans must be computed and allowed for. As very few vacuum balances exist, the latter method is usually employed. The data necessary for the computation are the latitude of the place where the weighing is made and its altitude above the sea-level; the weights, specific gravities, and coefficients of expansion of each of the substances in the two pans; the temperature of the air, its barometric pressure, and the pressure both of the aqueous vapour and of the carbonic anhydride contained in it.

Judging from the adjustment of the *pile de Charlemagne*, and the Exchequer troy weights of Queen Elizabeth, the accuracy attained in weighing gold and silver at the mints during the fourteenth, fifteenth, and sixteenth centuries must have been about 1 part in 10,000. The balance which Mr. Harris, of the London Mint, used in 1743 indicated one-eighth of a grain on a troy pound, or about one part in 50,000; while, according to Sir George Shuckburgh, the balance used by Messrs. Harris and Bird in making their observations upon the Exchequer weights, apparently in 1758 or 1759, turned with 1/230,000 part of its load. In 1798, Sir George Shuckburgh had a balance sensitive enough to indicate 0·01 of a grain when loaded with 16,000 grains, or about one part in 1,600,000. The balance used by Fortin in 1799, in adjusting the kilogramme of the Archives, was not quite so delicate, its sensitiveness being only the 1,000,000th part of its load; but in 1844, for the adjustment of the present English standard pound, Prof. Miller employed a balance whose index moved about 0·01 of an inch for a change of 0·002 of a grain in a load of 7000 grains. He read the index with a microscope, and found the probable error of a single comparison of two avoirdupois pounds to be 1/12,000,000 of either, or about 0·00058 of a grain. At the present time it is claimed that two

[1] This table has been deduced from the data given by Prof. Miller in Phil. Trans., 1856, p. 760.

avoirdupois pounds can be compared with an error not exceeding 0·0002 of a grain, and two kilogrammes with an error not exceeding 0·02 of a milligramme.

The mean solar day is the natural unit of time for the human race, and it is universally adopted among all civilized nations. Our ultimate standard of time is therefore the rotation of the earth upon its axis, and from that rotation we determine the errors of our clocks and watches by astronomical observations. For many purposes it suffices to make these observations upon the sun, but when the utmost precision is desired it is better to make them on the stars. Until the close of the seventeenth century, quadrants were employed for that purpose, and so late as 1680, Flamsteed, the first English Astronomer-Royal, thought himself fortunate when he succeeded in constructing one which enabled him to be sure of his observed times within three seconds.[1] About 1690, Roemer invented the transit instrument, which soon superseded the quadrant, and still remains the best appliance for determining time. Most of his observations were destroyed by a fire in 1728, but the few which have come down to us show that as early as 1706 he determined time with an accuracy which has not yet been very greatly surpassed. Probably the corrections found in the least square adjustment of extensive systems of longitude determinations afford the best criterion for estimating the accuracy of first-class modern time observations, and from them it appears that the error of such observations may rise as high as ± 0·05 of a second.

During the intervals between successive observations of the heavenly bodies we necessarily depend upon clocks and chronometers for our knowledge of the time, and very erroneous ideas are frequently entertained respecting the accuracy of their running. The subject is one upon which it is difficult to obtain exact information, but there are few time-pieces which will run for a week without varying more than three-quarters of a second from their predicted error. As the number of seconds in a week is 604,800, this amounts to saying that the best time-pieces can be trusted to measure a week within one part in 756,000. Nevertheless, clocks and chronometers are but adjuncts to our chief time-piece, which is the earth itself, and upon the constancy of its rotation depends the preservation of our present unit of time. Early in this century Laplace and Poisson were believed to have proved that the length of the sidereal day had not changed by so much as the 100th part of a second during the last 2500 years, but later investigations show that they were mistaken, and, so far as we can now see, the friction produced by the tides in the ocean must be steadily reducing the velocity with which the earth rotates about its axis. The change is too slow to become sensible within the lifetime of a human being, but its ultimate consequences will be most momentous.

Ages ago it was remarked that all things run in cycles, and there is enough truth in the saying to make it as applicable now as on the day it was uttered. The Babylonian or Chaldean system of weights and measures seems to be the original from which the Egyptian system was derived, and is probably the most ancient of which we have any knowledge. Its unit of length was the cubit, of which there were two varieties—the natural and the royal. The foot was two-thirds of the natural cubit. Respecting the earliest Chaldean and Egyptian system of weights, no very satisfactory information exists, but the best authorities agree that the weight of water contained in the measure of a cubic foot constituted the talent, or larger unit of weight, and that the sixtieth or fiftieth parts of the talent constituted, respectively, the Chaldean and Egyptian values of the mina, or lesser unit of commercial weight. Doubtless these weights varied considerably at different times and places, just as the modern pound has varied, but the relations stated are believed to have been the original ones. The ancient Chaldeans used not only the decimal system of notation, which is evidently the primitive one, but also a duodecimal system (as shown by the division of the year into twelve months, the equinoctial day and night each into twelve hours, the zodiac into twelve signs, &c.), and a sexagesimal system (by which the hour was divided into sixty minutes, the signs of the zodiac into thirty parts or degrees, and the circle into 360 degrees, with further sexagesimal subdivisions). The duodecimal and sexagesimal systems seem to have originated with the Chaldean astronomers, who, for some reason which is not now evident, preferred them to the decimal system, and by the weight of their scientific authority impressed them upon their system of weights and measures. Now observe how closely the scientific thought of to-day repeats the scientific thought of four thousand years ago. These old Chaldeans took from the human body what they regarded as a suitable unit of length, and for their unit of mass they adopted a cube of water bearing simple relations to their unit of length. Four thousand years later, when these simple relations had been forgotten and impaired, some of the most eminent men of science of the last century again undertook the task of constructing a system of weights and measures. With them the duodecimal and sexagesimal systems were out of favour, while the decimal system was highly fashionable, and for that reason they subdivided their units decimally, instead of duodecimally, sexagesimally, or by powers of two; but they reverted to the old Chaldean device for obtaining simple relations between their units of length and mass, and to that fact alone the French metric system owes its survival. Everyone now knows that the metre is not the 10,000,000th part of a quadrant of the earth's meridian; and in mathematical physics, where the numbers are all so complicated that they can only be dealt with by the aid of logarithms, and the constant π, an utterly irrational quantity, crops up in almost every integral, mere decimal subdivision of the units counts for very little. But in some departments of science, as, for example, chemistry, a simple relation between the unit of length (which determines volume), the unit of mass, and the unit of specific gravity, is of prime importance; and wherever that is the case the metric system will be used. To engineers such relations are of small moment, and consequently among English-speaking engineers the metric system is making no progress, while, on the other hand, the chemists have eagerly adopted it. As the English yard and pound are the direct descendants of the Chaldean-Babylonian natural cubit and mina, it is not surprising that the yard should be only 0·48 of an inch shorter than the double cubit, and the avoirdupois pound only 665 grains lighter than the Babylonian commercial mina; but, considering the origin of the metric system, it is rather curious that the metre is only 1·97 inches shorter than the Chaldean double royal cubit, and the kilogramme only 102 grains heavier than the Babylonian royal mina. Thus, without much exaggeration, we may regard the present English and French fundamental units of length and mass as representing respectively the commercial and royal units of length and mass of the Chaldeans of 4000 years ago.

Science tells us that the energy of the solar system is being slowly dissipated in the form of radiant heat; that ultimately the sun will grow dim; life will die out on the planets; one by one they will tumble into the expiring sun; and at last darkness and the bitter cold of the absolute zero will reign over all. In that far-distant future imagine some wandering human spirit to have penetrated to a part of space immeasurably beyond the range of our most powerful telescopes, and there, upon an orb where the mechanical arts flourish as they do here, let him be asked to reproduce the standards of length, mass, and time, with which we are now familiar. In the presence of such a demand the science of the seventeenth and eighteenth centuries would be powerless. The spin of the earth which measures our days and nights would be irretrievably gone; our yards, our metres, our pounds, our kilogrammes would have tumbled with the earth into the ruins of the sun, and become part of the *débris* of the solar system. Could they be recovered from the dead past and live again? The science of all previous ages mournfully answers, No; but with the science of the nineteenth century it is otherwise. The spectroscope has taught us that throughout the visible universe the constitution of matter is the same. Everywhere the rhythmic motions of the atoms are absolutely identical, and to them, and the light which they emit, our wandering spirit would turn for the recovery of the long-lost standards. By means of a diffraction grating and an accurate goniometer he could recover the yard from the wave-length of sodium light with an error not exceeding one or two thousandths of an inch. Water is everywhere, and with his newly recovered yard he could measure a cubic foot of it, and thus recover the standard of mass which we call a pound. The recovery of our standard of time would be more difficult; but even that could be accomplished with an error not exceeding half a minute in a day. One way would be to perform Michelson's modification of Foucault's experiment for determining the velocity of light. Another way would be to make a Siemens's mercury unit of electrical resistance, and then, either by the British Association method, or by Lord Rayleigh's modification of Lorenz's method, find the velocity which measures its resistance in absolute units. Still another way would be to find the ratio of the electro-static and electro-magnetic units of electricity. Thus all the units now

[1] Account of the Rev. John Flamsteed. By Francis Baily. Pp. 45-9 (London, 1835, 4to.)

used in transacting the world's business could be made to reappear, if not with scientific, at least with commercial accuracy, on the other side of an abyss of time and space before which the human mind shrinks back in dismay. The science of the eighteenth century sought to render itself immortal by basing its standard units upon the solid earth; but the science of the nineteenth century soars far beyond the solar system, and connects its units with the ultimate atoms which constitute the universe itself.

SCIENTIFIC SERIALS.

The *American Meteorological Journal* for July contains an article by Prof. H. A. Hazen on storms and a central-ascending current. The author discusses a few of the arguments for and against the theories of storm formation, viz. the theory of an ascensional current in the centre of a storm, and that of the increase of energy, through the liberation of latent heat and consequent production of a partial vacuum. Some of the conclusions arrived at are that the theories are exceedingly unsubstantial, and that, above all things, positive information of the processes going on in upper air strata is necessary; that the dependence of the generation of storms on temperature distribution in a vertical direction appears open to doubt; and that, reasoning from the behaviour of thunderstorms, it seems possible that some electrical action, not thoroughly understood, supplies the force which keeps up their energy.—Mr. A. L. Rotch contributes an article on the organization of the Meteorological Service in Holland. The Institute at Utrecht existed as a private establishment as early as 1849, and its Director, Dr. Buys Ballot, first stated publicly in 1857 the relation between wind and atmospheric pressure in the law which bears his name. Dr. Buys Ballot has for many years endeavoured to combine trustworthy observations all over the world with each other, and has published, in his "Year-book," detailed observations for various distant parts. Branch offices are established at Amsterdam and Rotterdam, and the collection of observations made at sea is actively carried on. At present the work bears upon the South Atlantic in connection with the Deutsche Seewarte, and, independently, upon the Indian Ocean.—Prof. C. F. Marvin continues the discussion between himself and Prof. Hazen as to the cause of differences obtained in anemometer experiments. Prof. Hazen attributes them to the influence of the natural wind blowing at the time, while Prof. Marvin thinks this of little importance and calculates its effect by a formula. He thinks that the momentum theory of the cups explains the discrepancies in a satisfactory manner.—Lieut. J. P. Finley contributes tornado statistics for the State of Iowa for fifty-two years ending 1888.

SOCIETIES AND ACADEMIES.

London.

Entomological Society, August 7.—The Right Hon. Lord Walsingham, F.R.S., President, in the chair.—Prof. C. V. Riley, of Washington, was elected an Honorary Fellow in place of the late Dr. Signoret, of Paris.—Mr. Walter F. Blandford exhibited a specimen of *Cardiophorus cinereus*, taken at Tenby, and remarked that the species had rarely, if ever previously, been found in the United Kingdom. Mr. C. O. Waterhouse said he believed that there was a specimen in the collection of his late father, and also another specimen in the collection of the British Museum.—Mr. Waterhouse stated that the British Museum had just received from the Rev. A. Elwin, of Hangchow, China, a luminous larva about 1½ inch long, and 3½ lines broad, which he believed to be one of the *Lampyridæ*.—Lord Walsingham exhibited specimens of *Conchylis degreyana*, McLach., bred from seed-heads of *Plantago lanceolata* at Merton, Norfolk; also a specimen of *Tineidæ* allied to the genus *Solenobia*, probably belonging to *Dissoctena*, Staud., but differing somewhat in the structure of the antennæ. He said that the specimen was taken by himself at Merton on July 31 last, and that the species was apparently undescribed.—Herr Meyer Darcis exhibited a collection of Coleoptera, comprising specimens of a species of *Locthrus* from Turkestan; *Julodis globithorax*, Stev., from the Caucasus; a new species of *Julodis* from Kurdistan; *Cardiaspis Mouhotii*, Saunders, from Sikkim; *Carabus smaragdinus*, Fisch., from Siberia; *Julodis ampliata*, Mars., from Aintab, Asia Minor; and *Julodis luteogramma*, Mars., from Syria, and a variety of the same from Kurdistan.—Mr. H. Goss read extracts from letters from Mr. R. W. Fereday, of New Zealand, and Sir John Hall, K.C.M.G., relating to a number of Lepidoptera recently collected at sea, about half-way between the River Plate and Rio, at a distance of over 250 miles from land, in about 30° S. lat. and 46° W. longitude. It was stated that the ship was surrounded by swarms of moths. Mr. J. J. Walker, R.N., observed that he had seen large numbers of insects at sea about 150 miles off the coast of Brazil, and he referred to other records of the capture of insects at sea in Darwin's "Voyage of the *Beagle*," and Dr. Carpenter's "Cruise of the *Alert*." The discussion was continued by Dr. Sharp, Lord Walsingham, Mr. White, and Mr. Kirby.—Mr. E. Meyrick read a paper entitled "On some Lepidoptera from New Guinea," and exhibited the species described in the paper. He stated that the specimens were derived from two sources, viz. (1) a portion of the collection received by the Society from Baron Ferdinand von Müller, F.R.S., and collected by Mr. Sayer when accompanying the Australian Geographical Society's Exploring Expedition; and (2) a number of specimens collected by Mr. Kowald near Port Moresby.—Mr. Blandford read a letter from Mr. Wroughton, of Poona, asking for assistance in working out certain Indian Hymenoptera and Diptera in the collections of the Bombay Natural History Society. Lord Walsingham, Colonel Swinhoe, and Mr. Moore made some remarks on the subject.

Paris.

Academy of Sciences, July 29.—M. Des Cloizeaux, President, in the chair.—On a means of studying the natural history of the river-eel after its migration from fresh to salt water, by M. Émile Blanchard. It was shown by the author many years ago that, during its sojourn in fresh-water lakes and rivers, the eel remains in an immature state, incapable of reproduction. With a view to completing its life-history, he now suggests that large numbers should be taken on their way seawards, labelled with a little metallic plate, and then returned to the water, in the hope that a few so marked may afterwards be captured at intervals in the sea, and thus enable zoologists to follow their complete evolution. To give effect to this project, he seeks the co-operation both of Government and naturalists.—On the variations of latitude in the solar spots, by M. R. Wolf. Attention is directed to pp. 84–91 of No. 73 of the *Astronomische Mittheilungen*, where the author infers, from his studies of solar physics, that the abrupt change of latitude noticed at the epoch of the minimum does not depend exclusively on the period of $11\frac{1}{9}$ years, but also on the longer period of $66\frac{2}{3}$ to $88\frac{1}{3}$ years. This longer period determines the altitude of the maxima, so that the extent of the change in latitude and the altitude of the ensuing maximum increase or diminish simultaneously. Hence the change of latitude recorded by Spoerer for the second half of the seventeenth century would not appear to have been anomalous, but merely the result of the low maxima reached at that time. — On the transmission of power by alternate currents, by M. Maurice Leblanc. But for the difficulties caused by the phenomena of self-induction, alternate currents might be advantageously employed for transmitting power, as they may easily receive the highest tensions, while they do not alter the insulators, as is the case with continuous currents. The author here describes an apparatus by means of which he hopes that these difficulties may be obviated.—On the conductibility of electrolytes at very high temperatures, by M. Lucien Poincaré. The methods employed by MM. Bouty and Poincaré in their experiments on the electric conductivity of salts in solution cannot be directly applied beyond the melting-point of glass. But, by various dispositions here detailed, M. Poincaré has been enabled to obtain measurements to within about one-fiftieth of absolute accuracy.—On a new method of volumetric analysis for silver, mercury, and thallium, by M. Adolphe Carnot. Chemists possess excellent processes for the volumetric analysis of silver, but very defective ones for that of mercury. M. Carnot here describes a new method, based on the use of potassium iodide, which is about equally applicable to both of these metals, as well as to thallium.—Researches on the sulphites, by M. P. J. Hartog. Despite the difficulty of its preparation, the author has succeeded in obtaining an anhydrous and crystallized sulphite of potassa in large quantities. By the same process, which is described in detail, he has also prepared the sulphite of soda in the same form, but not in a pure state, and the double normal sulphite of potassium and soda. The preparation of other sulphites will be described in a future communication.—Synthesis of some selenium compounds in the aromatic series, by M. C. Chabrié. The syntheses here undertaken are those in which the metalloid is united directly with the carbon of the cyclic nucleus. By making selenium tetrachloride act on benzine, M. Chabrié has obtained compounds corresponding to the sulphides and thiophenols prepared by Friedel and Crafts from sulphur and the chloride of sulphur.—On the oxidizing action of nitroso-camphor under the influence of light, by M. P. Cazeneuve. This substance, recently obtained by the author (*Comptes rendus*, cviii. p. 857), yields Liebermann's blue reaction with phenol and sulphuric acid, and also presents the curious phenomenon of becoming decomposed under the influence of light. The conditions seem somewhat analogous to those attending the formation of chlorophyll and of the colouring-matter in flowers.—On the isocamphols, by M. A. Haller. The paper deals more particularly with the influence of solvents on the rotatory power of the isocamphols.—Respiratory combustion by the nervous system in its relation to the size of the animal, by M. Charles Richet. A large number of experiments on dogs confirm, for animals of the same species, the law established by Regnault and Reiset for animals of different species—namely, that the respiratory combustions, by kilogramme of living weight, increase in inverse ratio to the size of the animal.—On the products of microbes favourable to the development of infections, by M. G. H. Roger. Amongst the substances secreted by Bacteria, some are known to produce intoxicating phenomena, while others possess vaccinating properties. M. Roger's researches lead to the inference that there are others that tend to stimulate the development of certain pathogenic agencies, at least in the case of symptomatic charbon.—On a new Mediterranean species of the genus Phoronis, by M. Louis Roule. This specimen was found in the Zoological Station at Cette, and has been named *Ph. sabatieri*, from the founder of that station. The characteristics of the species are here described by contrast with *Ph. hippocrepis*, Str. W.—On the growth of the oceanic sardine, by M. Georges Pouchet. Observers have failed to determine the region where the sardine is hatched and passes the first phases of its development. Those reaching the fishing-grounds are already several months old, and the observations made at several points present so many discrepancies that no general law can be laid down regarding their growth during the fishing season. The difficulty of determining this point is increased by the fact that the shoals themselves appear to be continually renewed by fresh arrivals throughout the whole season.

August 5.—M. Des Cloizeaux, President, in the chair.—Heat of combination of fluor with hydrogen, by MM. Berthelot and Moissan. After many failures, the authors have at last succeeded in measuring the heat of combination of these bodies. Reserving for a future communication the details of their experiments, they here give the broad results expressed in the formulas :—

$$H + F \text{ gas} = HF \text{ gas} \quad \ldots \quad + 37{\cdot}6 \text{ calories}$$
$$H + F = HF \text{ dissolved} \quad \ldots \quad + 49{\cdot}4 \quad ,,$$

—On the relations of atmospheric nitrogen with vegetable soil, by M. Th. Schlœsing. Continuing his researches on this subject with fresh samples of earth taken from various districts and under varying conditions, the author has still failed to discover any soil which being destitute of vegetable germs fixes gaseous nitrogen. Hence he concludes that if any exist they must be regarded as quite exceptional, and not to be depended on by agriculturists.—Observations of Davidson's comet (July 23) made at the Observatory of Algiers, by MM. Trépied, Sy, and Renaux. The observations cover the period from July 26 to July 30, when the nucleus of the comet was comparable to a star of the eighth magnitude.—A study of the electric phenomena produced by solar radiations, by M. Albert Nodon. Numerous observations made at the laboratories of the Sorbonne and the Collège de France show that on meeting an insulated metallic or carbon conductor the solar rays communicate to it a positive electric charge ; that the amplitude of this charge increases with the intensity of the rays, and decreases with the hygrometric state of the air, the phenomenon attaining its maximum value in Paris about 1 p.m. in summer, when the atmosphere is pure and dry ; lastly, that the effects cease during the transit of clouds across the face of the sun. If these results can be extended to non-metallic bodies, then solar radiation may be regarded as one of the causes of the electrization of the clouds.—Researches on the sulphites (continued), by M. P. J. Hartog. Here are studied the double normal sulphites of potassium and ammonium, and the bisulphite sulphite of sodium and potassium.—On the heat of combustion of some organic compounds, by M. J. Ossipoff. The bisubstituted succinic acids, presenting certain analogies with the fumaric and malic acids, are here studied thermochemically with a view to determining their heat of combustion.—A chemical and thermic study of the phenolsulphuric acids (continued), by M. S. Allain Le Canu. In the present paper the author confines his researches to orthophenolsulphuric acid, the preparation and properties of which are fully described.—On the distribution of Nemertes on some points of the French seaboard, by M. L. Joubin. A systematic exploration of the Roscoff and Banyuls districts has resulted in the discovery of nearly sixty species of Nemertes in those two localities alone. About ten of these have not yet been described, and will form the subject of a future memoir.—On the mechanism of the photodermatic and photogenic functions in the siphon of *Pholas dactylus*, by M. Raphael Dubois. Although these mollusks possess no eyes, they display extreme sensibility to light, the least change of its intensity sufficing to excite a more or less sudden contraction of the siphon. M. Dubois's already described graphic process has enabled him to verify the existence of two distinct functions, one receptive, the other emissive, thus showing that the mechanism of sight belongs to the category of tactile phenomena in the higher animals gradually differentiated and localized in a special organ. It also appears that the photodermatic (receptive) function is stimulated by luminous vibrations from without, while the photogenic (emissive) has for its final outcome the emission of luminous rays through the circumambient medium.—On some habits of the sea trout, by M. A. Giard. The author's observations in the Wimereux estuary and neighbouring waters, tend to show that many smelts and grilses, and even a number of adults (bull-trout ?), pass a much longer time in the sea than is generally supposed by ichthyologists.—On the colouring matter of the spermoderm in the Angiosperms, by M. Louis Claudel. The results are here given of a series of studies on the pigments of grains made in the botanical laboratory, Marseilles. It appears generally that the solid pigments of grains are scarcely ever presented under the form of leucite, and that they derive directly from the protoplasm. In this respect they differ from the pigments of flowers and pericarps which, according to Flahault and others, derive from pre-existing leucites.—On the recent eruption of the island of Vulcano (Lipari Group), by M. O. Silvestri. The volcanic phenomena presented by the eruption, which began on August 2, 1888, are characteristic of a special phase, which has already been observed by M. Silvestri at Etna, and to which he proposes to give the name of *Vulcanian phase*.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Practical Photometry: W. J. Dibdin (King).—Picture-Making by Photography, 2nd edition: H. P. Robinson (Hazell).—Shut out from Love: J. Nickal (Hughes).—Éléments d'Économie Politique Pure, deuxième édition: L. Walras (Lausanne, Rouge).—Lehrbuch der Vergleichenden Anatomie, Zweite Abtheilung: Dr. A. Lang (Jena, Fischer).—Cours de Minéralogie, deuxième édition: A. de Lapparent (Paris, Savy).—Chemical and Physical Studies in the Metamorphism of Rocks; A. Irving (Longmans).

CONTENTS.

THURSDAY, AUGUST 22, 1889.

AFRICAN FARM PESTS.

Notes and Descriptions of a Few Injurious Farm and Fruit Insects of South Africa. Compiled by Eleanor A. Ormerod, F.R.Met.Soc., &c. (London: Simpkin, Marshall, and Co., 1889.)

MISS ORMEROD is indeed energetic. Not content with waging bitter war against the destructive pests of British crops, she extends her campaigns to far distant lands. Although applications of farmers for information as to the attacks of many injurious insects arrive incessantly from all parts of the United Kingdom, Miss Ormerod finds time to deal with the complaints of cultivators in all other parts of the world, and surveys insects from China to Peru. In 1887 an elaborate treatise upon a scale-insect (*Icerya purchasi*) which seriously injures vines, fig, orange, peach, and other trees and shrubs in Australia, was published by Miss Ormerod, giving full scientific details as to the life-history of this coccid, and as to methods of prevention and remedies likely to be beneficial. Just recently another work has appeared, entitled "Observations on some Injurious Insects of South Africa," written in Miss Ormerod's usual clear and interesting style, and admirably illustrated. From this we propose to take some extracts to show the cosmopolitan entomological knowledge of the authoress, as well as to give some idea of the enemies of cultivated plants in "Afric's golden sands."

The first reflection that arises from the perusal of this book, and of others descriptive of the usual plagues which follow in the wake of civilized cultivation, is that no clime nor culture under the sun is exempt from them. No sooner had orange groves been formed in the suitable lands of Florida than various scale-insects swarmed upon the trees. The purple scale, the white scale, the red scale, and the "chaff" scale, among others, threatened to ruin the crops and to kill the trees, until remedies were discovered by the skilful economic entomologists of the United States.

In the newly made tea plantations of Assam a red spider (*Tetranychus bioculatus*) has suddenly shown itself, and threatens serious mischief to the plants, unless some wash can be invented which will kill the spiders, and leave no taste in the tea-leaves.

So in Africa, scale-insects, especially the *Icerya purchasi*, have within the last few years, as shown by Miss Ormerod, extensively spread in Cape Colony, upon oranges, lemons, vines, and other kinds of fruit-trees. This scale-insect has also now become one of the most dangerous pests infesting fruit-trees in California. It is the opinion of Prof. Riley, the United States Entomologist, that the *Icerya purchasi* originated in Australia. There was some doubt at first as to this. It was thought that it came from Mauritius; but it was discovered that it was the species known as *Icerya sacchari* which was imported from thence upon sugar-canes to California.

Frequent and rapid communication between countries, and the general interchange of commodities of all kinds, have undoubtedly disseminated insects throughout the world. Thus the Hessian fly was brought from the United States with straw in packing-cases, and the flour moth (*Ephestia kuhniella*), has been recently imported into England from some European country, as the authorities conclude.

At the same time it is considered that the conditions of cultivation adopted in these days, being somewhat of a forcing and unnatural nature, favour the increase of insects, and, in a degree, predispose plants to their attacks, which become more varied and intensified year by year not only in this country but in all others. It is of the greatest importance, therefore, that cultivators should be advised by competent persons as to the life-histories of these crop destroyers, and as to measures to be taken to prevent their spread, and remedies to be used against them.

Miss Ormerod has arisen, a very *Dea ex machinâ*, and for several years has given timely instruction and advice to agriculturists of many nations, just as Professors Riley, Lintner, and Comstock have helped the tillers of land in the United States to detect and combat the onslaughts of many crop-destroyers. Prof. Lindeman is doing the same good work in Russia, Dr. de Man in the Netherlands, Dr. Taschenberg in Germany.

And in this her latest work, "Notes and Descriptions of Injurious Farm and Fruit Insects of South Africa," Miss Ormerod conveys much practical information which can be readily understood and easily utilized. At the same time it is scientific enough for entomologists, and interesting to those who are not cultivators or men of science.

Miss Ormerod explains her reasons as follows for publishing this account of African farm pests, though no explanation appears necessary for such a valuable service:—

"About four years ago, Mr. J. D. Bristow, President of the East Province Natural History Society of Cape Colony, wrote to inquire whether, if I were furnished with notes regarding pests of the crops in East Province, Cape Colony, I would publish them. At that time there was not the opportunity which there now is of procuring sound and clear directions for treatment of insect as well as other attacks of crops and stock, by reference to the *Agricultural Journal*, published by the Department of Agriculture of Cape Colony, therefore I willingly agreed to do my best, in case trustworthy agricultural observations could be procured, and specimens of the insects referred to also sent for identification. Specimens of about fifty kinds of insects were sent over, of which a few proved to be of undescribed species; and I have given in the following pages, as far as I can, figures and observations of habits and means of prevention of some of the pests, and means by which they might be identified."

The first insect described is one of the well-known dangerous family *Melolonthidæ*, to which the familiar British cockchafer belongs. The scientific name is *Eriesthis stigmatica*, but it is commonly termed the "mealie," or maize, chafer, as it is the worst pest in the country for crops of maize, and destroys it from near Fort Beaufort right down to the Fish River mouth. This is very much smaller than the cockchafer, and smaller, too, than the rose chafer (*Cetonia aurata*), which is, however, of a different family.

Another chafer, *Hypopholis sommeri*, injures vines considerably, probably by devouring the leaves, in the perfect state, and feeding on the roots, in the larval state. It is

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much larger than the "mealie," of a red-brown colour, and, "judging from the number of specimens usually contained in collections received from South Africa, this would appear to be a very common species in that country."

It is desirable to destroy the insects belonging to this family both in their beetle and larval conditions. In the former case they may be shaken down from the trees and shrubs upon which they rest in a sluggish state during the day. The larvæ can be reduced in numbers by digging round the roots of the infested plants. "In Ceylon," Miss Ormerod remarks, "where the grubs of various kinds of chafers do much harm to coffee-plant roots, it is noted that on one estate a gang of coolies was employed to dig them out of the ground (for they are always near the surface at the end of the feeding rootlets), which they did at the rate of about a quarter of a bushel per man per day. Lime, salt, and carbolic acid were tried without effect, I believe."

Some species of Melolonthidæ, especially the common cockchafer (*Melolontha vulgaris*), are so destructive to trees, vines, and other plants in France, that the French Minister of Agriculture has recently issued orders to the various prefects to take steps to reduce their numbers.

A beetle of the family *Dynastidæ*, styled *Heteronychus arator*, and the "keever" by the farmers, is the most widespread and destructive of the African pests, according to a correspondent, being a subterraneous worker, attacking wheat by eating away the roots. In length of body it is from 12 to 15 millimetres, and resembles the British beetle *Aphodius fossor*, belonging, however, to a quite distinct family, of which no member occurs in Britain.

They are rarely seen above ground, biting off the wheat plants about an inch under ground. It will be plain to all practical persons that this insect must be a very difficult foe to deal with, as it comes out of the ground and flies about trees during the night, and retires to the wheat roots during the day. Miss Ormerod states that it is also found in St. Helena, and it is more particularly to be met with along the sides of roads near hay-fields and grass-lands, where it may often be seen dead in considerable numbers, "which points to this 'keever' beetle being a grass as well as a corn pest, and may give some clue as to where to look for their grubs, as in common course of things beetles die just after having laid their eggs." It is recommended to dress wheat plants thus attacked with paraffin and sand, or ashes, or dry earth, to prevent the attack of this beetle.

Two other beetles, the *Pentodon nireus* and *Pentodon contractus*, injure the wheat crops. They are larger than the *Heteronychus arator*, but are similar in their method of attack. Neither of these appears to have any common or local name.

Yet another beetle, belonging to the family of *Cetoniidæ*, in which the British rose chafer is grouped, and defined as *Rhabdotis semipunctata*, a pretty insect with a bright green upper surface marked with white lines and spots, causes much injury to the blossoms of apple and plum trees, and later on to ripening peaches and figs. In some parts it is so plentiful that the only peaches and figs saved were those tied up in muslin bags. Miss Ormerod suggests that the only measures against this insect are to catch the beetles in nets when flying in the sunshine, as is done in England, and destroying their grubs at the roots of trees and plants.

Among other Coleoptera figured are the *Mylabris oculata*, a large, handsome black beetle, with red or yellow bands, of the family *Cantharidæ*, possessing the same vesicating properties, and sadly troublesome to peas and beans and fruit blossoms. Also a *Bruchus*, an unknown species, but which Miss Ormerod conjectures may be *subarmatus*, Gyllenhal. "Of the British *Bruchi* this species is most nearly allied to *Bruchus loti*." From Miss Ormerod's careful account of its larva, it does not much differ from that of *Bruchus pisi*.

This species of *Bruchus* infests peas and beans just in the same manner as the British *Bruchus rufimanus*.

> "Its attack is seriously hurtful. In two of the beans figured above, I found four holes showing where the beetles had escaped; in another seven beetles had been present, and in another I found five beetles, or coloured chrysalids, still within. Mr. Bairstow reported that this pest when in larval condition reduces the interior of the seed to a fine powder, and passes into a pupa, sometimes in its powdery bed, which disappears almost immediately on the emergence of the perfect insect."

Miss Ormerod gives an elaborate account of the modes of attack of this *Bruchus*, which do not much differ from those of its British congener. Also, it is recommended that infested beans should be steeped in a solution of Calvert's carbolic acid, so diluted as not to damage the seed.

Among the destructive Lepidoptera, butterflies and moths, in South Africa, the large handsome *Papilio demoleus*, or orange butterfly, figures prominently. The larvæ of this insect eat the leaves of orange trees, appearing "generally at the end of November, or beginning of December, and in greater numbers on trees whose lower branches are allowed to trail on the ground. It is advisable to cut all branches one foot above the ground, to turn as often as possible the soil within a circle of one foot from the trunk, keeping it moist, and to watch for the grubs, which are large, and of a yellowish-green colour, during the summer season."

The caterpillars of a moth, *Trilocha ficicola*, belonging to the *Bombycidæ*, cause much damage to fig trees by eating their leaves and nascent buds. For this attack, hand-picking is advised, and turning over the soil beneath the trees where the cocoons may be.

The "diamond-back" moth (*Plutella cruciferarum*), so well known in Britain, is a source of much trouble to Cape cabbage-growers, for which Miss Ormerod prescribes nitrate of soda applications to push on the growth of the plants, and sweeping the infested plants with boughs fixed to a scuffler.

To fruit-growers, the orange fly "Trypeta" (*Ceratitis citriperda*) is a bitter enemy. "In some districts last year," Mr. Hellier writes, "Albany amongst the rest, four-fifths of our peaches, apricots, figs, and plums were uneatable." The fly deposits some half-a-dozen eggs in a fruit when it is getting ripe. From these maggots come, and soon render the fruit useless. Concerning its life-history, Miss Ormerod quotes Prof. Westwood's remarks, from which extracts will be received with much interest by all economic entomologists.

"The perfect insect is one of the most beautiful of the order to which it belongs; the male is singularly distinguished by having two slender filaments arising between the eyes, knobbed at the tips, a peculiarity which we believe is possessed by no other dipterous insect, and which is wanting in the female. The larva is a white, fleshy grub destitute of legs, very similar to the celery fly, and like it possesses two small black hooks at the front of its body, which it alternately protrudes and retracts, thereby tearing the delicate membrane in which the drops of juice are contained. There are generally several of these larvæ in each orange, and when removed and placed upon a flat surface, they have the power of springing to a considerable distance, in the same manner as the well-known cheese-mite. When full-grown they eat their way out of the orange, and undergo the change to the pupa state on the outside."

Prof. Westwood adds that the presence of infestation might be inferred sometimes by a puncture not larger than that made by a pin, but generally surrounded with a withered and discoloured spot varying in size from sixpence to half-a-crown.

Miss Ormerod characteristically observes:—

"One main point of information wanted to check attack is, Where does the maggot in natural circumstances undergo its changes to the chrysalis state? It might be found out very easily whether the maggots drop to the ground, by laying cloths smeared with any sticky material, which would prevent their straying away, beneath a few of the infested trees. Any fruit that is infested should not be allowed to remain on the ground to continue the attack, and if on investigation it should prove that the later maggots go into the chrysalis state in the ground, or even that a large proportion of them do so—or if it could be found where the flies generally hibernate—these points would help greatly in lessening attack."

Ostrich-farming, extensively adopted in South Africa, is much hindered by "a terrible pest," in the shape of the ostrich flies, of which sometimes there are "thousands on the ostriches, and that they irritated the birds so that half of their time was taken up in pecking at the flies, and that, judging from the increase in the last two years, if something was not done to destroy them, the feathers would not be worth sending to market, and the writer believed that in time they would destroy the birds."

The fly in question is akin to the "forest fly" (*Hippobosca equinæ*), which is found upon horses and ponies in the New Forest, in Hants. These get accustomed to the flies, and make no special demonstrations concerning them; but a horse which is strange to their attacks goes half mad when one of these insects gets upon it.

In the case of ostriches, Miss Ormerod considers tobacco decoctions, soapsuds, and other washes applied to the birds would be found to succeed. McDougall's dip has been used, and Miss Ormerod thinks that sulphur would be useful.

Cattle ticks (*Amblyomma hebræum*), of the family *Ixodidæ*, some of them three-quarters of an inch long by three-eighths wide, described as the "disastrous hide perforators of these regions," sadly vex the South African cattle, so that it would indeed be a boon to the country if any means could be discovered to destroy, or, what would be better, "prevent the presence of a little creature which moves a market downwards at a high percentage."

The most interesting part, perhaps, of this work is that which deals with some of the *Coccidæ*. First among these is the "Australian bug" (*Icerya purchasi*), which was noticed in the Botanic Garden at Cape Town in the latter half of 1873, and has now spread over 680 miles in the eastern provinces of Cape Colony. Where it came from, Miss Ormerod says, it does not appear, "but there is not room for doubt that the attack was set on foot by imported specimens, and that it rapidly became naturalized. It attacks" orange trees, vines, fig trees, deciduous fruit-trees, ornamental shrubs, and garden plants, even strawberry plants.

The life-history of this insect is remarkable. When the female, a salmon-coloured, tortoise-shaped insect, with six legs and long antennæ, is one-sixth of an inch long, it secretes snow-white cotton-like matter, which is formed under the mother for the covering and protection of its eggs. For some time the female moves about, but after a while all movement is arrested, and the insect seems glued to one spot. In time the eggs are hatched, and larvæ, as many as 200 often from one female, go forth to find congenial food upon the plant, and in turn lay eggs in the same manner. The eggs are not hatched at once, but the process continues for several weeks. In the meantime the mother shrivels up, and becomes a mere dead husk, covering the eggs and hatching young. The whole process extends over many weeks, and gives ample opportunity for immense damage to be caused.

The male is rarely seen. It has wings more than a fourth of an inch in expanse; its body is about the eighth of an inch long, orange-red in colour, with long ten-jointed antennæ. Prof. Riley gives the best account of the male insect, stating that it is "fond of shelter, and will get under any projecting piece of bark or under bandage placed round the tree, often creeping under clods of earth. It is rather sluggish during the day, remaining motionless in crevices of the bark or wedged in between females on the tree. There seems, in fact, a well-marked attempt at concealment. At the approach of night they dart rapidly about on the wing, swarming round infected trees."

Miss Ormerod prescribes various washes as remedies against this and other coccids, and gives a list of insect enemies, which are happily numerous and formidable. The larva of the "golden eye" (*Chrysopa perla*) is most useful, destroying the young "Australian bug" just at hatching-time within the sac of the female. The Chrysopa also devours quantities of Aphides which infest hop plants in England. Species of ladybirds (*Coccinellæ*) are by far the best friends to African cultivators. They are invaluable in destroying the perfected young in the nidus of the female "bug," just as they, both as larvæ (niggers) and perfect insects, eat myriads of hop Aphides in the English plantations.

There are other insects which do good service in keeping down this *Icerya*, described by Miss Ormerod, of which, however, there is not space to give any account. Other destructive and useful insects have not been alluded to for the same reason, but those who take an interest in economic entomology will do well to peruse this instructive little book, and extract for themselves its valuable contents.

THE FOREST FLORA OF NEW ZEALAND.

The Forest Flora of New Zealand. By T. Kirk, F.G.S., late Chief Conservator of State Forests to the Government of New Zealand, &c. Folio, 345 pages and 160 plates. (Wellington: By authority; George Didsbury, Government Printer, 1889.)

MR. EDWARD BARTLEY states[1] that only four kinds of New Zealand timber are used in Auckland for building purposes, and that these are: kauri (*Dammara australis*), rimu (*Dacrydium cupressinum*), totara (*Podocarpus totara*), and kahikatea (*Podocarpus dacrydioides*); but Mr. Kirk's "Forest Flora" goes far beyond the timber-yielding element of the New Zealand forests. It illustrates and describes nearly the whole of the shrubby and arboreous plants of New Zealand, and gives very full particulars of their dimensions, qualities, uses, distribution, and propagation. It is by no means a mere compilation; and, although the author acknowledges various sources of information, a slight examination of the work is sufficient to convince us that it is very largely based upon personal observation, and that the details are elaborated with great care.

Altogether the flora of New Zealand contains rather less than a thousand species of flowering plants, and of these 115 are illustrated in the present work; some of the more important and specially interesting species by several plates. The tree ferns, which form so conspicuous a feature in the vegetation of the country, are not included, and some shrubby plants are omitted whose claims to notice are at least equally as strong as some of those admitted; but this is explained by the author's desire to do the work thoroughly as far as he went. For this reason, several of the small shrubby Coniferæ are figured, and a considerable number of plates are devoted to the illustration of the heterophyllous members of various natural orders.

Heterophylly is not a peculiar feature of insular floras, though it is perhaps nowhere more conspicuously developed than it is in New Zealand and Rodriguez.[2] Many of the New Zealand Coniferæ, the most valuable of the timber-trees, exhibit this peculiarity in a high degree, insomuch that different parts of the same tree have been referred to different species and even to different genera. Thus different parts of *Dacrydium Colensoi* might represent a juniper and a cypress, while in *D. Kirkii* there is a still more remarkable dimorphism. In explanation of Plate 97, Mr. Kirk writes:—

"As in the preceding species (*D. Colensoi*), the foliage is of two kinds, but the difference is of a still more striking character. The lower branches are spreading, the upper ascending or erect, the ultimate branchlets forming fan-shaped masses. The lower branches, sometimes to the height of 40 feet, are clothed with long narrow flat leaves; the upper branches are clothed with small scale-like, closely appressed leaves; so that the lower part of the tree resembles a silver-fir, while the upper part puts on the appearance of a cypress."

Figures are given of the dimorphic foliage of these conifers, and the confusion in nomenclature which has arisen in consequence of one kind only having often been taken by collectors is unravelled. It should be added that it is only the cypress-like branches that bear flowers and fruit.

In these New Zealand Coniferæ the foliage is dimorphic, but in several plants belonging to other natural orders it is polymorphic. Noteworthy among these are several members of the Araliaceæ, also *Rubus australis* and *Hoheria populnea*, of the order Malvaceæ. Mr. Kirk has very fully illustrated some of these remarkable plants, devoting five plates to the last-named, and as many to *Pseudopanax crassifolium* (Araliaceæ), a plant not unknown in cultivation in this country. The earliest leaves following the cotyledons of this *Panax* are small, narrow, and sharp-pointed, with entire margins; "but the leaves next produced are very different: they are distinctly stalked, 1 to 2 inches in length, rhomboid or elongate rhomboid in shape, and sharply toothed or deeply lobed, bearing some resemblance to those of the common hawthorn. Succeeding leaves are longer and of uniform width, until they sometimes attain the length of 3 feet 6 inches, while they scarcely exceed half an inch in width and are invariably deflexed. In this stage the leaves are thick and leathery in texture and acute at the apex, with distant sharp marginal teeth." This is the form in cultivation in this country, sometimes called the fish-bone tree, which Sir Joseph Hooker named *Panax longissimum*, as it had retained its peculiar character unchanged for fifteen years; though subsequent investigation proved that it was no other than *P. crassifolium*. In this stage of development the stem is invariably unbranched, and rises to a height of 20 feet; and, as it often retains its leaves almost to the base, it presents a very remarkable appearance. Following these long, narrow, undivided leaves, come others composed of three to five separate leaflets, and borne on petioles from 1 to 5 inches in length. The leaflets are less stiff than the long leaves, narrower, and having sharply-toothed margins. These are succeeded by similar leaves on longer petioles, having broader leaflets, thicker in texture, with coarser, more distant teeth. Flowers are sometimes produced at this stage, but not unless the stem has given off lateral branches. In the usual flowering stage the leaves have again become simple, and they gradually become thicker, the toothing almost wholly disappears, and they are from 4 to 6 inches in length, and borne on short stout petioles. To add to the perplexities of the plant, the male and female flowers are borne on different individuals. It is not surprising, therefore, that botanists working with herbarium specimens only have failed to limit or define the species correctly. As already stated, many other New Zealand plants are remarkable for the great variability of their leaves at different stages of development, and the kind of variation is as diverse as the extent of it.

There are so many other interesting subjects in Mr. Kirk's book that one is at a loss which to select for notice. Specially noteworthy is the presence in New Zealand of three species of *Fuchsia*, a genus otherwise restricted to America; and remarkable among these is *F. excorticata*, which sometimes attains a height of 45 feet, with a gnarled trunk up to 3 feet in diameter. The Central American *F. arborescens* is the only species that equals or approaches it in dimensions. *F. excorticata* has

[1] "The Building Timbers of New Zealand," Transactions and Proceedings of the New Zealand Institute, xviii. p. 37.

[2] For particulars of the latter, see Dr. Bayley Balfour's account of the botany of the island in the Philosophical Transactions of the Royal Society of London, vol. clxviii., 1879.

medium-size flowers, at first of a greenish colour streaked or blotched with purple, and finally of a dull red, with very small, almost black petals. The tube of the calyx is very much constricted immediately above the ovary, and there is a second constriction a little higher up. Moreover, the flowers are trimorphic in the relative lengths of the style and stamens. That this *Fuchsia* yields "one of the strongest and most durable timbers in the colony" will be news to most people. But, as the trunk is often crooked or gnarled, it is difficult to procure logs exceeding 8 or 9 feet in length, and its commercial value is therefore greatly diminished. Mr. Kirk says the wood is hard, dense, compact, and even, and deep brown in colour, relieved by streaks of a paler shade, and short narrow waved black markings. When much waved, it is of a highly ornamental character. Further, it is almost indestructible even by fire, except in a closed furnace.

Many more interesting facts might be extracted from this admirable book, the botany of which appears to be equally as good as the practical part. A few new species are described, and the female flower of *Podocarpus totara* and the male catkin of *Dacrydium cupressinum* are figured and described for the first time.

One more point deserves mentioning. Mr. Kirk is very much concerned about the many inappropriate popular colonial names, which he proposes to reform; but we think he has undertaken a task in which he must inevitably fail. From the time of the earliest settlements, the various species of native beech (*Fagus*) have been called red birch, white birch, &c., though not uniformly throughout the colony; and the Maori language has only one common name for all the species. Now, Mr. Kirk proposes calling them "entire-leaved beech," "tooth-leaved beech," and so on. Supposing it were possible to effect a reform in this direction, the substitution of such uncouth names as those proposed is less to be desired than the retention of their present botanically inaccurate appellations.

W. Botting Hemsley.

AN ELEMENTARY TEXT-BOOK OF CHEMISTRY.

An Elementary Text-book of Chemistry. By William G. Mixter. Second and Revised Edition. (London: Macmillan and Co., 1889.)

THIS volume belongs to the well-known series of "Manuals for Students," and will pleasantly surprise those who imagine that the multitude of elementary text-books of chemistry has made originality impossible. Of those smaller matters that readers and students generally accept with no more thought than their daily mercies, the index deserves especial mention as being exceptionally inclusive, and bearing evident signs of having been compiled by someone who had a sufficient knowledge of the subject to go beyond the mere verbiage, and enough patience to carry the task through.

Looking at the book simply as a treatise on chemistry, the adoption of the periodic system as a method of classification is very desirable, but the difficulty as to which of its elements a compound shall be associated with is not easily settled. The tendency is doubtless to keep the compounds of any one metal together, and this is what the author has done as far as possible, but as, for example, nine metals are treated of before oxygen and sulphur, and thirty-eight metals before carbon, the compounds of those metals that are considered in the earlier pages are spread through the book in a manner that is doubly confusing, the interpolated sections seriously interfering with the general arrangement. The sulphates of sodium, for instance, cannot be considered with sodium itself before sulphur has been mentioned, nor can they be added to sulphuric acid, as that would disturb the natural sequence of sulphur, selenium, and tellurium compounds, and the best place remaining for them is in the middle of one of the groups of elements. As a natural result of this apparently unavoidable irregularity, such a common salt as manganese sulphate finds no place at all, and it cannot be supposed that it is intentionally omitted when manganese tetrafluoride, hydrogen auryl sulphate, gold sulphate, and other equally rare compounds have considerable space allotted to them.

There is another marked innovation that certainly deserves success—namely, the introduction of gravimetrical quantitative experiments. The very first experiment in the division of the book headed "Chemistry" is the preparation of hydrogen by the action of sodium upon water, and the student is directed, after weighing the sodium and measuring the gas, to calculate the relative weights of the two, making all due corrections. In the next experiment the proportion between the weights of equivalent amounts of zinc and hydrogen is determined.

If the volume before us were simply an experiment in text-books, we might leave off here by congratulating the author on the measure of success that he has realized; but his first words in the preface are, "This work is designed for use in schools and colleges." The tendency at the present time is not merely to introduce the study of chemistry, but to extend the general scope of education in many other ways, so that the time devoted to chemistry has been very much reduced in some cases to allow of the addition of other subjects to the student's carriculum. It would be difficult to find a student who would have time to work through 238 experiments in elementary chemistry, especially when many of them are in reality a combination of three or four; and besides the specific experiments enumerated there are suggestions in the text that the student should prepare certain compounds and verify their properties. We do not hesitate to say that the intelligent performance of a fifth of the number of experiments set down to be done, accompanied with suitable study, would give the student as serviceable a knowledge of the subject as if he went through the mass of practical work prescribed.

The author also says in his preface that "Graphic and constitutional formulas are much used," and the body of the book fully bears out the statement. Graphic formulæ have been perseveringly tried in this country as an aid to the elementary student of inorganic chemistry, and have been deliberately discarded as uselessly cumbrous, and as making what is difficult to the beginner more difficult still. Such formulæ, however, are occasionally useful; but we would ask what good end is served by setting down the graphic formula of $Na_4W_3O_{11}$, which is given at p. 190? The best formula is that which most simply expresses the properties of a compound, but it would be difficult to say what properties are indicated by such formulæ as that referred to.

There are a few statements on important subjects that at the present time concern no one but the historian. For example, the classification of salts as normal, acid, or basic, according to the proportion between "the bonds of the acid radical" and "the bonds of the basic radical," was never generally accepted, and is now universally allowed to be an altogether faulty method. The extraordinary prominence given to hydrogen dioxide or "free hydroxyl," which has four pages devoted to it, while sulphuric acid has little more than two, is scarcely justifiable, we think, at the present time. But on the whole, the book is a useful compendium of the principal properties of not only the more important substances but also of many of the compounds of the rarer elements.

OUR BOOK SHELF.

A Treatise on Geometrical Conics. By A. Cockshott and Rev. F. B. Walters. (London: Macmillan and Co., 1889.)

THIS work is not intended to supersede such works as Besant and Taylor, which, being drawn up for University students, naturally cover a good extent of ground, but to meet what is a pressing need in school teaching. The need of some recognized sequence of propositions, as our authors state, has long been admitted. It was with a view to meet this need, as we have previously stated in this journal, that the Association for the Improvement of Geometrical Teaching published its syllabus of the subject, which had been accepted by the Association at its annual meeting in January 1884. The work before us has been drawn up in accordance with the syllabus, the authors' aim being to invest the skeleton of the syllabus with suitable raiment. A main feature of the outline was the prominence given to Adams's property (which boys will call Adam's property), the S U K I (now changed rightly, as O is used for the external point, to the S U O I) proposition. In the parabola, we are told we may employ the property in proving tangential propositions; in the case of the ellipse and hyperbola, the authors use Adams's, and also give two other constructions. But this is a matter of detail. The proofs are neat and well suited to beginners. A capital feature is the appending quite elementary riders to the respective propositions, these not being too difficult; and in most cases, being true riders on the propositions they follow, they will encourage the young student to prosecute a study which becomes very fascinating when once the student gets a grasp of it. A short chapter on orthogonal projection follows that on the parabola, and is likely to be of use as showing the intimate connection which exists between the circle and the ellipse. A large collection of Cambridge problems, duly labelled, closes the work.

We have waited long for this quasi-authorized edition of the Association's syllabus, "thereby hangs a tale," and now it has reached us we are not disappointed. There are very numerous figures, many of which are excellent, but others are like Pharaoh's lean kine, "very ill-favoured."

Phormium tenax as a Fibrous Plant. Edited by Sir James Hector, K.C.M.G., M.D., F.R.S., &c. With Plates. Second Edition. (Wellington, New Zealand: By authority, George Didsbury, Government Printer, 1889.)

THE original edition of this little hand-book appeared in 1872, since which period a great deal of consideration has been given in this country to the further development of vegetable fibres generally, amongst which New Zealand flax or hemp has had its share. The book has such a varied amount of authentic information on the subject with which it treats that the appearance of a new edition is a distinct gain to those—and they are many—who are occupied at present in the investigation of vegetable fibres.

The description of the *Phormium tenax*, its habit and rate of growth, cultivation, transplanting, and propagation, with an account of the native and European methods of preparing the fibre, are all brought together here in a compact form. The reports, prepared in New Zealand by Messrs. Skey, Nottidge, and Hutton, together with those of Profs. W. R. MacNab and A. H. Church, prepared in this country, are also very valuable. These latter appear in full in the new edition, and the former are in some particulars more detailed. The book is, however, almost a reprint of that which appeared in 1872, in some cases even to the reproduction of errors; thus on p. 2 of both the old and new editions the Raupo, *Typha angustifolia*, is printed *Typhus*.

The most interesting part, at the present time, of Sir James Hector's new issue is, in consequence of its being the newest matter, the preface, from which we learn that during the last two years the demand for *Phormium* fibre has been steadily on the increase, and that one important application is for the production of twine for use in the harvesting machine, it having been found that as a substitute for wire in reapers and binders no fibre is equal to it.

Revision of the British Actiniæ. By Prof. A. C. Haddon. Part I. (London: Williams and Norgate, 1889.)

THIS revision of the British sea anemones by Prof. Haddon, will be welcomed by all students of this interesting group. We know a good deal already of our native species, thanks to the writings of Sir J. Dalzell, Dr. George Johnston, and P. H. Gosse; and the last-mentioned author, in his well-known "History of the British Sea Anemones and Corals" (1858), succeeded, by the aid of chromo-lithography, in giving very fair representations in colours of the living forms. But the "Report on the Actiniaria of the *Challenger*," by Richard Hertwig, in which he sought by anatomical investigations to establish a scientific classification of the group, opened up a new standpoint for the study of these forms, of which Prof. Haddon has most wisely and energetically availed himself; and in this first part of his revision we have a most excellent monograph of the *Chondractininæ*, and studies of several genera, which may be regarded as more or less representing the various stages in the evolution of the typical hexamerous Actiniæ. These latter belong to the families *Edwardsidæ* and *Halcampidæ*. There is also a description of the remarkable *Gonactinia prolifera*, Sars, some notes on *Zoantheæ* and on the development of Actiniæ.

Chitonactis marioni, *Paraphellia expansa*, *Edwardsia tecta*, and *Halcampa arenarea*, are described and figured as new species.

Seven plates accompany this memoir, of which the first two, representing *Chitonactis marioni*, n. sp., *Gephyra dohrnii* (von Koch), *Actinange richardi* (Marion), *Paraphellia expansa* (g. et sp. nn.), *Halcampa arenarea* (n. sp.), *Chondractinia digitata* (Müller), and an undescribed species of *Sagartia*, are very beautifully printed in colours, being perhaps the most life-like illustrations of Actiniaria as yet published in the Transactions of any of our learned Societies.

This memoir forms Part V. of the fourth volume of the Royal Dublin Society's Transactions.

Practical Iron-Founding. By the Author of "Pattern-Making," &c. (London: Whittaker and Co., 1889.)

THIS little volume is an attempt to give, in a condensed form, an account of the principles and practice of iron-founding. To begin with, iron-founding is an art most difficult for the non-professional man to understand, even when going through a foundry, where the various branches of the work are going on before his eyes. How much more difficult it must be for a student to get much real knowledge of the art from a book it is easy to imagine.

As an elementary hand-book this volume will, no doubt, serve its purpose. At the same time, it ought to be clearly understood that the iron-foundry is the only place where iron-founding can be learned thoroughly. A little idea of the art may be obtained by other means, but moulding, of all the engineer's arts, is the one which requires the practical work in an engineer's foundry for its development. The machine tool is largely to blame for the deterioration of our skilled workmen generally, but this has been least felt in the foundry. The moulder must still have his trade between his fingers to be efficient, and no amount of machinery as at present designed will help him to mould, say, a pair of locomotive cylinders in one casting. The book is carefully written, and represents good all-round practice as far as it goes. The illustrations of tools, &c., are clear and accurate.

N. J. L.

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.*]

Ice Blocks on a Moraine.

BLOCKS of ice, so far as I know and so far as I remember to have read, are not usual constituents of a moraine. So it may be well to call attention to an instance which I saw lately when walking over the Gorner Glacier with my friend Mr. J. Eccles, who is even more familiar than I am with glaciers, and to whom the sight was novel. At the base of Monte Rosa, where it begins to rise from the Gorner Glacier, are two buttresses of ice-worn rock; the northern called *Ob dem See*, the southern *Auf der Platte.* Between these a glacier, evidently of no great thickness, descends towards the west, and adjacent to each, rather on the in-side, as it may be called, is a little lake. In the northern of these (called the Gorner See, and the only one some five-and-twenty years ago, if I remember rightly) several blocks of ice are now floating; not far from it are the blocks on the moraine.

To explain how they attained their present position, in some cases more than a hundred yards from the water, and probably quite twenty above it, a little more topographical description is needed. The moraine of which they form a part is not a ridge composed of, or at least masked by stones, but a very gentle swell of ice, over which, especially on the eastern side, blocks are scattered in open order. It extends from one lakelet to the other, and is produced as follows. As said above, the glacier which passes between these rock-buttresses is by no means a thick one, but the southern flank of Auf der Platte is swept by a huge ice-stream which descends from the snow-fields of the Lys-joch, and is prevented from much lateral expansion by the pressure of a second large glacier which drains the northern face of the Zwillinge. This enormous mass of ice tends to pond back the smaller glacier; thus the moraine, mentioned above, is mainly formed by the left lateral moraine of the latter, by a few blocks which come down its mid stream, and possibly by the right lateral moraine of the Lys Glacier. The obstructed ice, however, is forced up so as to form a sort of flattened wave, so that if one were coming right down the face of Monte Rosa one would mount 50 or 60 feet from the margin of the Gorner See, or perhaps half as much from the middle part of the Monte Rosa glacier, and then, after a slight descent, would again ascend a gentle slope in order to arrive on the broad united ice-stream which bears the name of the Gorner Glacier.

The blocks of ice are numerous. A few of the largest must contain about 8000 cubic feet—many vary from 2000 to 5000 cubic feet—indeed, in the northern part of the moraine I think the ice exceeds the rock in actual volume. These ice-blocks, in some cases, are mounted on ice-pedestals, just as is rock in a glacier-table; the support rising perhaps a couple of feet above the level of the glacier. Of course they were "perspiring" freely under a July sun, and do not make a long journey; probably few succeeding in getting a furlong away from their source.

That these blocks of ice began as bergs in the Gorner See is indubitable. They have been elevated to their present position by the strugggle between the confluent ice-streams; the smaller of these impinging upon the larger almost at right angles, and being thus forced upwards by the obstacle. The number of the blocks suggests the possibility that the glacier itself may form part of the bed of the Gorner See; for they would be more readily removed from the water, if the actual bed of the lakelet, instead of being at rest, were slowly travelling forward and upward.

The above description illustrates the way in which (as I have seen suggested) blocks of rock in past geological ages may sometimes have been carried up-hill by glaciers. At the same time I may observe that I should myself be reluctant to found upon it any very sweeping generalization.

T. G. BONNEY.

The Inheritance of Injuries.

IN the notice of Dr. Weismann's "Ueber die Hypothese einer Vererbung von Verletzungen" (NATURE, July 25, p. 303) there occurs the following commentary:—It is not so certain that all will admit Weismann's contention that the demolition of the inheritance of injuries furnishes strong presumptive evidence that acquired characters are not inherited. *It might well be urged that there is a great distinction between characters which are obviously not useful (such as injuries) and useful characters.*"

I have italicized the last sentence, desiring to call the attention of those interested in the subject to some points of difference between useful and not useful or disabling variations, as these may be supposed to lend themselves to transmission by inheritance. The appreciation of these points of difference is calculated, I believe, to greatly assist in settling the important question as to the inheritance of acquired characters.

In my work on "Dissolution and Evolution and the Science of Medicine" (Longmans and Co.) an attempt is made to show from various considerations that non-congenital diseases, including injuries, are not inheritable. The chief contention is that diseases and injuries are simply disorganizations of pre-existent functions and structures. They are not, as useful and normal characters are, integrated and organized arrangements of the organism's energies, but bodily disintegrations inseparable from the actions of the environment. Diseases as dissimilar as a common burn and general paralysis of the insane, are shown, in the work I speak of, to be alike in so far that they are disintegrations of the body and causally related to the environment. It is this intrinsic nature of disease and injuries and their dependence on external conditions which goes far, as I believe, to make them uninheritable. Since my work is probably accessible to few of the readers of NATURE, I may perhaps be permitted to quote the following extracts as further argument and illustration.

"True diseases, as we have just seen, cannot be separated from their causes; and causes, being of the environment, are not handed down. But there are additional reasons for the feeble hold which heredity has upon pathological states. When we discriminate between the variations of function and structure that are passed on by parent to offspring and those that are not, we are forced to see that natural selection, working always in confederation with heredity, seizes upon *favourable* variations. Natural selection appropriates organismal acquisitions. But analysis discloses the fact that diseases are losses, not gains; are unfavourable variations, and offer no 'purchase' for the co-operative influence of these two modes of action. . . . But more important than influences of this sort is that influence which springs from the differences of nature and conditions between normal and abnormal traits. Normal structures were evolved in long periods of time, and have been transmitted through generations unnumbered; therefore, the tendency to their perpetuation by inheritance must be immensely predominant over any tendency to the perpetuation by inheritance of the transitory changes of disease. I believe that the 'vestiges' of once useful structures owe their astonishing persistence to the fact that they have become deeply pressed into the organic arrangement by the selection and transmission of such structures for secular periods. This makes intelligible the rarity with which deprivation of a limb or other part leaves any impress upon offspring. Though circumcision has been practised among the Jews for ages, it has not produced congenital preputial imperfection in the race.

Nor do we ever find that amputation of a limb, or loss of the cortex of the kidney from Bright's disease, is followed by corresponding anatomical deficiencies in children. In the African transported to northern latitudes, the dark skin persists through indeterminable generations—provided there is no cross-breeding—but the endemic diseases of his race are not transported with him.

"Hitherto all reasoning upon the heritableness of diseases has proceeded on the tacit assumption that morbid changes are subject to the same laws of vital action as healthy changes. It has been discovered, however, that the two are dissimilar both in nature and in the circumstances of their genesis. The traits we every day recognize as inherited are the results of an infinity of co-ordinate actions. There may be instanced the bony framework of the face, the colour of the iris, the gait, special mental aptitudes. All these, and attributes of the same order, represent a vast integration of forces, groups of organized energies. It is this organization which gives them individuality and makes their hereditary transmission possible. They are, in other words, self-existent, having been independent of the original conditions out of which they grew."

The conclusion, deduced from evolutionary principles, that non-congenital diseases and injuries are not inheritable, might, I think, be supported inductively from the facts of medical observation, and it is most interesting that the results of Dr. Weismann's investigations are confirmatory. But from what has been said it clearly appears, in harmony with the annotation I commenced by quoting, that the non-inheritance of injuries is no evidence of the non-inheritance of acquired useful variations. C. Pitfield Mitchell.

24 De Vere Gardens, W.

Classified Cataloguing.

Whenever a collection has been catalogued anew, and all the numbers are in the museum order of the specimens, the placing of additions at the end, without any sequence but that of acquisition, always seems a melancholy collapse of the order just established. So strongly is this felt that some curators even enter additions with the same numbers as similar specimens, distinguished by letters, as 3247*a*; but, as formerly in the British Museum, this system breaks down when such additions far outnumber the original series, and we reach figures like 3247*fy*. At the same time this is an approach to an entirely different and logical system of cataloguing, which ought to be considered. Another stage of arrangement has been by appropriating so many thousand numbers to each branch, so that the articles of one class may have contiguous numbers.

The complete system of cataloguing which has been thus felt after, and sought for, is what may be called "fractional cataloguing," treating all numbers as decimal fractions and arranging them accordingly. Thus 21·765, 21·77, 21·8, and 22 might appear as successive numbers in a catalogue: the numbers being arranged solely by their successive order of the left-hand figures, regardless of the length of the number. By this system, therefore, any quantity of additions can be brought into their right order without disturbance; fifty new specimens like No. 371, for instance, being numbered 371·01 to 371·50.

The first two or three places of the number will therefore indicate the nature of the specimen in any given catalogue: and this leads at once to the desirability of all collections having a similar numerical basis for their catalogues, so that if all the parrots, for instance, begin with 56 in one collection they should do so in all other museums.

The first step therefore in classified cataloguing would be to agree on a set of 100 or 1000 numbers, to subdivide each branch of science, the distribution of the numbers being partly settled by the average number of specimens, partly by natural divisions. Thus in mineralogy, elements might be 001 to 099; binary compounds 100 to 299; silicates 300 to 799; non-metallic acid salts 800 to 899; metallic acid salts 900 to 999. In all museums, then, silicates, say of lime, magnesia, and alumina, would begin with 61, the different species being marked 610 to 619, and varieties and individual specimens numbered with additional decimals following these bases, *e.g.* 615·47. The set of numbers in each science would be best fixed by a committee at some International Congress, so as to insure general acceptance, like the scheme of geological colouring.

The disadvantages of this system would be—(1) that the catalogue would have to be kept like that of a library, subject to additions at any point, and therefore on slips which could be transferred; and (2) that the total number of specimens would not be known except by counting. These are not serious difficulties, and the following advantages seem to entirely out-weigh them.

(1) The numbers would indicate to all students the nature of the specimens quoted in any collection. (2) The catalogue would be classified in natural order throughout, so that all similar specimens would be described together. (3) The numbers in the museums would be in order from end to end. (4) Any specimens moved could be rearranged by unskilled assistance, solely by the numbers. (5) Any object in the catalogue or hand-books could be at once found in the museum by its number. (6) A great help would be given to the arrangement of minor museums by having a uniform scheme of cataloguing fixed. (7) The numbers being in constant use would soon form technical symbols for species, a short-hand briefer than chemical symbols even, and applied to all sciences; and also a valuable key to the memory.

Bromley, Kent. W. M. Flinders Petrie.

Head Measurements of Students at the University of Cambridge.

I was rather too precipitate when I stated that the figures relied on by Mr. Galton were totally inadequate to support his conclusions; for, as regards the second of them, viz. that the "high honour" man has a head perceptibly larger than the "poll" man, the evidence is fairly strong; but with regard to the other three conclusions, referring to the growth of heads, I must repeat what I have said. In the light of the discussion given below of a large number of observations, I cannot even admit that the tables and curves given in Mr. Galton's paper (see Nature, vol. xxxviii. p. 15) give even "an approximately true idea of what we should find, if we had the opportunity of discussing a much larger number of observations."

Having heard that all the measurements taken have been indexed for reference, I went to the laboratory, and, by the kind permission of the custodian, copied out the head measurements of fifteen individuals, each of whom had been measured at least five times. In one case, measurements had been taken at seventeen times. The average number was 7·1.

Since the first case quoted in my last letter forms one of these, I had better point out that Mr. Galton's objection to it is unsound. He notes a grouping of the observations, which makes him suspect that "some peculiarity in the shape of the head caused doubt as to the exact line of maximum height." But the observations of height are 5·2, 5·3, 5·4, 5·5, 5·5, and 5·6; and show no grouping. Mr. Galton must have meant that the calculated products were grouped. This is the case, but could not be due to the cause he suspects, for that would cause grouping in the simple heights.

The fifteen series of measurements fully bear out the conclusions which I drew before from two only. The measurements of width vary 0·1, 0·2, or 0·3 inch, those of length vary to the same extent, and in one instance up to 0·4 inch, while the height in most cases varies 0·4 or 0·5 inch. In only two cases does it vary so little as 0·2 inch, while in one case it varies 0·7 inch. The last case (where the figures are 5·4, 5·6, 5·1, 5·8, 5·5) is partly accounted for by the fact that the first three observations were taken by one observer, the other two by a second. (The statement in Mr. Galton's original paper that all the measurements were taken by one observer, must have been due to misinformation.) I have calculated the probable error of each observation of the height of head for each series of observations, using the approximate formula

$$r = \frac{0·845\Sigma v}{\sqrt{n(n - 1)}},$$

and I find it on the average 0·095 inch. Since the average height is less than 5·5 inches, this error amounts to 1·7 per cent. If the error in length and width were each half of this, the probable error of the product would be about 2 per cent.

To test whether any of the variation found is due to actual growth, and not to accidental error, I have used the following method. Arrange all the measurements of any one individual in the order of the dates on which they were taken, and separate them into two equal groups. Take the mean measurements of the first set, and put opposite them the mean of the dates; then do the same with the second set. On subtracting these we can see at once whether the head has grown in any direction.

As an example, G. F. R., who was measured sixteen times, gave the following mean values:—

Date.	Width.	Length.	Height.
September 1886	5·91 ...	7·82 ...	5·74
October 1888	5·94 ..	7·81 ...	5·60
	+0·03 ...	−0·01 ...	−0·14

The differences show the alterations occurring in twenty-five months.

I have calculated the other fourteen cases in the same way, and find that if the growth in width of the whole fifteen be added together, and the same be done with the length and height, the totals are only

+0·24 inch in width,
−0·56 inch in length,
−0·82 inch in height.

The average period during which these changes took place was thirteen months.

These 107 measurements which I have discussed therefore show a small *diminution* in the head capacity as the individual grows one year older, but this is so small compared with the probable error, that the observations are quite consistent with the hypothesis that the head remains quite stationary.

Ten measurements of the height of one individual, taken at successive years from twenty to thirty, would give us a better idea of the normal growth during that period, than many times that number if each were taken on separate individuals, for the range of individual variation at any age far surpasses the amount of growth in any one of them. For the same reason I think that the above 107 measurements made on fifteen individuals furnish a surer answer to the question, "Does the head of a University student grow after the age of nineteen?" than ten times the number made indiscriminately, and simply grouped by age. F. M. T.

Trinity College, Cambridge, August 3.

The Supposed Connection between Distant Earthquake Shocks.

It is very commonly assumed, whenever seismic disturbances at different localities occur synchronously, that, however remotely they may be situated, there is necessarily a connection of some kind between the shocks, originating in a common cause. A forcible illustration of this fallacy, as I think, having recently appeared in your columns, I beg to take this opportunity of questioning the position so generally adopted, and of testing the validity of the involved theory of earthquake causation by the light of the evidence furnished in the concrete case which has been presented in support of it.

On April 18 a somewhat remarkable earthquake took place in Japan, at about the same time that some rather considerable shocks were registered at two seismic stations in Germany. These occurrences were ably treated from the point of view in question in NATURE of July 25 (p. 294), by Dr. E. von Rebeur-Paschwitz, of Potsdam, and argued to a final issue.

It is taken for granted, primarily, under this hypothesis, that every minor earthquake-shock at any given point is the effect, direct or indirect, of some more violent disturbance elsewhere, near or distant; and it is further supposed that the latter is, in its turn, a more direct result of a volcanic outburst at some special centre of activity, known or unknown. From this premise it must be inferred that no micro-seismic shock can ever take place otherwise than as a throw-off from some violent disturbance more or less remotely located. When we examine this conclusion, however, and consider more broadly the concomitant relations of earthquake phenomena, we shall, I think, find that it possesses no foundation whatever in facts, and that the hypothesis does not bear the strain of such evidence as may be adduced from recent observation. We know, for instance, (1) that seismic activity is an experience of almost daily frequency in some localities, as in Japan, obviously without relation to the volcanic eruptions which occasionally take place in near proximity; (2) that, on the other hand, volcanic explosions sometimes occur unaccompanied by any widespread upheaval or distant undulations; and (3) that the earth's crust is, moreover, subject to an apparently constant state of slight vibrations or micro-seismic palpitation, in parts of the globe where perceptible shocks are less commonly experienced.

In the light of these facts the theory under discussion might be readily disposed of as a foregone conclusion, but it will be more satisfactory to prove its fallacy by means of the evidence afforded by the earthquakes recorded in these pages as having taken place at Tokio and in Germany on April 18, especially as the data have been so completely recorded by Dr. von Rebeur-Paschwitz. After considering the details registered by the seismometers stationed at Potsdam and at Wilhelmshaven (distant about 220 English miles), he has applied himself to the problem of making these facts fit in with the record of a shock which was experienced at Tokio at nearly the same time. It is to be remarked that the only source of information respecting the latter shock is the note which appeared in NATURE of June 13 (p. 162), in which the information that a violent volcanic eruption was taking place at Vries Island, "possibly 60 miles off," is repeated from a note on the previous page where the island is spoken of under its local name, Oshima. Dr. von Rebeur-Paschwitz too hastily accepts the connection suggested, and upon this slender basis rests his whole argument.

Now it would certainly happen that any earthquake transmitting its effects to a locality on the opposite side of the earth would affect also, in varying degrees, all the countries along the line travelled by the seismic wave; and that a constant diminution in its force would be a characteristic feature of such a phenomenon. But what is the actual evidence in the case in point? We are told that at Tokio the maximum oscillation registered was no more than about 17 mm., while at Potsdam the greatest amplitude of oscillation is stated to have been 154 mm. The seismometers in use may possibly be different in type, but there is surely not such great difference in construction as to cause the complete reversal of the readings, as would be required also by the accepted theory; it may rather be accepted, no doubts being entertained, that the resultant figures may be fitly compared. But the conclusion arrived at is at once seen to be absurd, for the lesser shock at Tokio could not possibly produce the ninefold greater one in Germany; while no mention whatever is made of any intermediate effects being produced along the path of the wave. It is, moreover, especially stated (p. 163) that this particular shock at Tokio was by no means a strong one; its "peculiarity lies, not in its violence, but in the extreme slowness of its oscillations." Yet it is calculated by Dr. von Rebeur-Paschwitz that the mean velocity of transmission of the wave (occupying 1h. 4·3m.) was "2142 metres of propagation," which is really 167 metres above the mean of the different rates computed by the two authorities cited.

Again, the volcanic eruption of Oshima or Vries Island, at about 60 miles distance from the main island, which is said to have destroyed upwards of 300 houses, and killed 170 persons, took place, *not* on the 18th, but on the 13th and 14th of April (cf. pp. 162 and 179, where fuller details are given). Besides this difference in the dates, no exceptional earthquake shocks are reported to have occurred at Tokio during the eruption, and I fail to see the possibility of any connection between the two particular phenomena considered.

If there were any direct seismic connection between Japan and Germany, the latter country would surely be subject to regular transmissions of the shocks which prevail at Tokio. The ample data furnished suffice to prove that it is not the case. We are informed, in a postscript to the letter under consideration (p. 295), that several other shocks were recorded at both Potsdam and Wilhelmshaven about this period, viz. on April 5, 8, 15, 28, and May 31; at Potsdam *alone* on April 25, May 21, 25, and 26; and at Wilhelmshaven two shocks were felt on May 30, "probably connected with the English earthquake of this day." These various shocks were not experienced equally by the instruments at the two stations, and they do not even seem to have been necessarily connected throughout, for we are told that on May 30 there was "perfect steadiness at Potsdam," while four of the shocks mentioned were not felt at Wilhelmshaven.

It is curious to note that no connection is supposed in respect of other earthquakes, and of volcanic activity in nearer proximity in Europe, although several such occurrences have happened during the same period. Thus, on April 26, several shocks were experienced at Schaffhausen, &c. (NATURE, vol. xl. p. 84); on April 27, a "severe" one, lasting 4 seconds, was felt at Agram (*ibid.* p. 45), a district much subject to seismic disturbance; on April 30, there was one along the coast of Norway (p. 133); and on May 8, a "severe" one, lasting 3 seconds, took place at Plevje, in Bosnia (p. 84). From Dr. Johnston-Lavis we further learn that Vesuvius was in a state of active eruption during the end of April and the beginning of May (p. 34), but no relation is suggested even in this case, and it is quite evident that the facts do not serve to prove the connection assumed.

I do not wish to assert that in no case are synchronous earthquakes related, for we have undoubted evidence that certain shocks have been very *widespread* from a single centre (as the great Lisbon earthquake in 1755); but it is my belief that nearly every earthquake, whether large or small, is due to strictly local stratigraphical causes, quite irrespective of volcanic agency. Having made many fruitless attempts myself to co-ordinate different well-authenticated shocks, I have been compelled to disbelieve the theory of their general connection, and have now adduced sufficient evidence to show that the verdict pronounced by Dr. von Rebeur-Paschwitz, that "we may therefore safely conclude that the disturbances noticed in Germany were really due to the volcanic action which caused the earthquakes of Tokio," is not proven, and fallacious.

4 Mecklenburgh Square, W.C. WILLIAM WHITE.

The Sources of Nitrogen in Vegetation.

THE discrepancy between the results obtained in the experiments on plants grown in free air instead of closed vessels appears to be general, as stated in NATURE (p. 333). Some years ago I ventured to suggest an explanation of this, based on an observation made in the course of some investigations of atmospheric dust particles.

Sheets of paper, smeared with adhesive coatings, and shallow vessels of water, were laid on the ground in a garden near Willesden. The resulting catch included far more organic than inorganic matter, the organic matter consisting chiefly of small insects. The amount of these was surprisingly great towards the end of summer or beginning of autumn, quite sufficient, I think, to account for the varying results obtained by Sir J. B. Lawes and Prof. J. H. Gilbert, especially for the "eccentric" behaviour of the Leguminosæ—"sometimes the plants died of nitrogen hunger; sometimes, after a time of such hunger, they recovered and produced abundant growth." The explanation may be confirmed or refuted by exposing an unplanted layer of sterilized sand, or other soil, of the same area as that on which the experimental plants are growing, and comparing the gain of combined nitrogen in both cases. W. MATTIEU WILLIAMS.

The Grange, Neasden, August 16.

Do Cats Count?

AFTER reading all the accounts of the interesting experiments lately performed on the famous "Sally," I am persuaded the following incident may not be without a certain interest to some readers of NATURE.

About two weeks ago, the cat of a dairyman in this neighbourhood gave birth to three kittens. Next day, one of them was removed, during the mother's absence, and drowned. On returning from a foraging expedition, and discovering her loss, puss immediately set out in search, presumably, of the missing one. All her efforts in this direction, of course, proved fruitless; but, evidently determined to at least make up the right number, she did so, curiously enough, by carrying off, from its nest close by, a young hare, not more than a week old. This she is at present suckling side by side with her own kittens. In view of these facts the above question very naturally suggests itself.

Winchburgh, N.B., August 15. J. T. WALKER.

Anapophyses.

MY attention has been called to a statement by Prof. Cope (NATURE, July 25, p. 298), that anapophyses are "wanting from the vertebræ of anthropoid apes and man." He probably means that they are very feebly developed, which is true. I have found them, however, to exist distinctly in *Troglodytes* and *Simia* from the eleventh dorsal to the second lumbar vertebra, and in *Hylobates* from the tenth to the fifteenth trunk vertebra, and sometimes beginning as high up as the third dorsal vertebra.

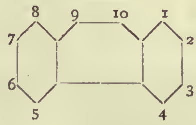
ST. GEORGE MIVART.

Hurstcote, Chilworth, August 12.

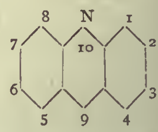
The International Chemical Congress—A Correction.

A MISPRINT has occurred in the notation adopted by the Chemical Congress for phenanthrene. The Secretary of the Nomenclature Section has also informed me that a slight modification has been made on the minutes, with regard to acridine, to make the notation adopted correspond more closely to that of the other "multi-ring" compounds. The two formulæ should be—

Phenanthrene.



Acridine.



YOUR CORRESPONDENT.

THE FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE eighteenth meeting of the French Association for the Advancement of Science opened under the happiest auspices. The magnificent Exhibition on the Champ de Mars and the Esplanade des Invalides, which has attracted to Paris an exceptionally large number of foreign men of science, is in itself the most conclusive proof of French energy and the progress of French science during the last decade. It is, perhaps, as M. de Lacaze Duthiers remarked, a more effective declaration of a sincere desire for peace than the utterances of certain diplomatists. But there is no place for politics in the principles of the French Association. Foreigners of all nations have been welcomed to Paris not only with warm-hearted hospitality, but with an artistic splendour of which they may well be envious for their own countries, and to which we shall allude later.

We may mention the presence of Messrs. J. H. Gladstone, F.R.S., R. McLachlan, F.R.S., Catalan, Candèze, Istrati, Berlinerblau, Orloff, Stephanos, Van Beneden, General Wauwermans, MM. Szabo, Valdemar Schmidt, Alexeieff, Bierens de Haan, Coleman, Colley, Franchimont, William Watson, Egoroff, Joukovsky, R. de Luna, A. Macfarlane, Ragona, Thomas Wilson, Benedikt, Hugo Gyldèn, Packard, Retzius, de Selys-Longchamps, Angström, Brusina, Flavitzky, Graebe, Dufour, Timiriazeff, von Goldschmidt.

The first meeting took place on Thursday, August 8, in the large hall of the Palais des Sociétés Savantes, which has just been erected by private enterprise in the quaint little rue Serpente which now affords a home to so many of the learned Societies of Paris.

The President of the Association for the year is the well-known Professor of Zoology at the Sorbonne, M. de Lacaze Duthiers, who chose as the subject of his inaugural address, "The Development of Zoological Method."

M. de Lacaze Duthiers began his address by thanking the Municipality of Paris for their invitation and for their generous subvention of £1200 recently voted towards the year's expenses. He then made a touching allusion to the foundation of the Association.

"It was one day in July 1871, that Wurtz, whose geniality and whose kindly vivacity you have not forgotten, took me, in his friendly way, by the arm, and said to me as we left the Academy of Sciences, 'Come to my house to-morrow night; I want to speak to some of our colleagues of a plan which I much wish to succeed.' On the Tuesday we met at M. Wurtz's house, just a few friends, MM. Delaunay, Claude Bernard, Decaisne, and myself. One may say that this was the first meeting of the French Association.

"As the only survivor of those who were our masters and our friends, I could not forbear from speaking to you of the intimate conversation in which our Association originated. I still seem to see and hear Wurtz with his kindling enthusiasm, with an activity at times feverish, but always good-hearted, striding across his drawing-room and giving us a picture of what our Society should, according to his idea, be—of what it has since become."[1]

M. de Lacaze Duthiers then proceeded to describe the state of zoology a hundred years ago.

"When 1789 came, Linnæus and Buffon had just died, and their fame was at its greatest splendour. They were the absolute masters of zoology, and the whole science was summed up in their work. Yet how different were the two in their nature and their work.

"Linnæus, precise, methodical, a classifier above all, introduced clearness and order into the most minute details of natural history, and as he proposed a nomenclature at once simple and precise his influence acquired such a preponderance that von Haller complained of his tyranny. If the reform of scientific language proposed by Linnæus took such immediate and powerful hold on the scientific world, it was because it exactly corresponded to the need of the moment.

"Before Linnæus, the objects of natural history were designated by the help of names or phrases formed by the addition of adjectives describing their characteristics, which overburdened the memory. All this he reduced to two words, just as in our families we distinguish the various members by a family name and a Christian name. The simplicity, the ease of application, and above all the opportune appearance of his nomenclature were the causes of its great success; but we must add that its intrinsic value is such that even to-day we hardly depart from the rules on which it is founded.

"The opposite of Linnæus, Buffon delighted in broad delineations, and his general reflections were animated by a potent inspiration. We are carried away and enthralled by the profundity of his thought, the elevated standpoint from which he views science. By reasoning and the consequences of observations which he interprets, he seeks as much to discover what will take place, and what must have taken place, as to determine the exact nature of what he observes. And thus he was often in advance of his epoch, and his lofty views could be understood only by the few.

"Linnæus, on the contrary, established *facts* with simplicity and clearness.

"With qualities such as these, these two men of genius, who died towards the end of the last century, must often have been at variance; and though the name had not yet been pronounced, we may already at this epoch distinguish between the school of facts and the school of theories (*l'école des faits et l'école du raisonnement*).

"But there was wanting to the works of Linnæus and Buffon a foundation whose necessity made itself imperatively and universally felt. For it was beginning to be perceived that the study of the habits, of the geographical origin, and of the external characters of animals was not sufficient.

"Then came Cuvier. It was the great merit of Cuvier to see clearly that if zoologists would arrive at a truer knowledge of animals, they must not content themselves with a description of their external forms, but must investigate their internal construction. It was thus that he introduced the notion of *anatomy* into natural history."

M. de Lacaze Duthiers proceeded to defend Cuvier's memory from unjust attacks which it had suffered owing to his opposition to Lamarck.

"Let us not judge great men by their weaknesses. By wishing to depreciate them, we often arrive at a contrary result, and lessen ourselves by a display of systematic and unjustifiable hostility. Let us see in them only what is good and great. And then we shall not fail to recognize the fact that Cuvier is entitled to our fullest meed of admiration."

The lecturer continued by pointing out that Geoffroy St. Hilaire and Lamarck occupied the same position with regard to Cuvier that Buffon had held with regard to Linnæus. Their speculations were too advanced, they came before their time.

"Zoology remained stationary for many years after Cuvier, and it was not before the beginning of the century that new ideas sprang up directing research along fresh paths, and profoundly modifying certain branches of biological science.

"It is strange to see how books and observations of considerable value often remain obscure for years, and are then finally brought to light by some unexpected discovery.

"I remember that about the year 1855 Prof. Huxley, the illustrious English *savant*, wrote to me (I was then Professor at Lille): 'In England we are all much excited about the discoveries of M. Boucher de Perthes.' You all remember the interest aroused by the discovery of the chipped silexes of St. Acheul, and the famous jaw of Moulin Quignon.

"English geologists came to Amiens. The most lively discussions took place, and an International Committee was formed to direct an official excavation.

"But perhaps the real discovery made, and this was due chiefly to the journey of the English *savants*, was that of the books, the researches, and the new ideas of Boucher de Perthes, which had hitherto passed almost unnoticed.

"We may say that from this moment dates the study of prehistoric times, which has undergone so immense a development. The excitement produced by the discoveries of M. Boucher de Perthes had begun to calm down, and researches were being pursued in every direction, when the first of Darwin's essays appeared in 1858 and 1859. These dates will remain for ever memorable in the history of natural science, for henceforward zoology (the only science of which I am at present speaking) takes an entirely new direction.

"We must acknowledge that whatever the measure of confidence we have in the theory of transformism, if we admit it to its full extent, with all its consequences, or if we reject it, it can be a matter of doubt to no one that this theory has led to a truly extraordinary scientific activity. Partisans and detractors both—in seeking for proofs of their opinions, either in the mysteries of embryology or in the investigation of the animal remains in geological strata—all, whatever their method, their ideas, their opinions, or their hostility, have caused zoology to take great strides.

"How far removed we are from the time of Linnæus, when external characteristics were everything—from the time of Cuvier, when anatomical notions and the study of exterior forms alone guided the classifier!

"To-day, what we seek for first of all is the enchainment of animals, either by going back to the forms of the past from those of the present, or the converse. We seek to explain the varied forms we see by the laws so happily formulated by Darwin—laws, indeed, which are as true as they are seductive.

"Who can deny the struggle for existence? Is it not to be found everywhere? And who will not admire the effects of selection? But why exaggerate its true bearings?

"Evolution is to be met with everywhere, in the civilized world as in the world of Nature, development is the great and eternal problem, resolved by the destruction of some, by the advancement of others; everywhere the struggle for life shows itself, inflexible and fatal.

"One may be a partisan or not of the theory of evolution—and I have not here to declare my own opinions, but rather to determine the exact influence of certain dis-

[1] It need hardly be said that Wurtz founded the French Association on the model of our British Association. From the war of 1870 dates a remarkable renaissance in French scientific activity, which had been in abeyance during the Empire, or at least till M. Duruy came into power in 1869 as Minister of Public Instruction, and founded that unique institution for the encouragement of research, the École des Hautes Études.

coveries and certain men on the progress of science—but one is forced to bow to facts, and to acknowledge the magnitude of the prodigious impulse given to science by the great English naturalist. But, as Claparède would say, there are *enfants terribles* of evolution—men more anxious to be spoken of than to discover the truth.

"We must carefully distinguish them from the conscientious men of science who investigate precise facts patiently, scrupulously, and laboriously, to deduce from them consequences in support of their theory. Men such as these make science advance surely, whereas the others sometimes compromise the cause.

"The only thing to oppose to exaggeration, the influence of excessive enthusiasm, is recourse to *experiment*. To-day, that is the great reform which we feel to be as necessary as those other reforms of whose history I have spoken."

Before developing this idea, the lecturer spoke of Lamarck, and of the reason why his ideas were not adopted during his lifetime.

"Of late years people have thought they had re-discovered Lamarck, and have severely blamed the generation of zoologists who neglected for half a century the author of the 'Philosophie Zoologique.'

"It is true that in the works of Lamarck there are whole pages which contain the theory of transformism completely developed, to which Darwin has added nothing, and which we may say he has but confirmed.

"But if Lamarck had not the satisfaction during his life-time of seeing his ideas admitted, it was that the minds of zoologists were not sufficiently prepared for them; it was that he had not the rare good fortune of finding a precise and lucid formula, whose truth is evident, and which is necessarily accepted by all.

"Some of Lamarck's conceptions of Nature are even difficult to understand, and especially to make clear to others; and I do not see that even his most ardent admirers have insisted on this portion of his work, and yet it is by no means inconsiderable.

"We should have been glad to see it more clearly explained than it is in the original, and brought within the comprehension of all, and one wonders why it should never be referred to.

"For a reformer to succeed, his idea must be striking in brilliancy and precision; it must master us by its intrinsic seduction.

"Take Darwin, showing us the struggle for existence taking place everywhere and at every instant, and leading to the selection and survival of the victor.

"Take Cuvier, who, it was said, reconstructed an extinct animal from a fragment of bone. A statement like this appealed to the imagination of the masses, and he excited the admiration of a whole generation when he compared an organism to an equation of which we may determine the unknown by the known quantities it contains.

"If Lamarck did not have the success he deserved, it was because of the abstract form he gave to his opinions, and the often *naïve* proofs which he adduced in confirmation of his theories at a moment when enthusiasm and popular attention were diverted to another aspect of science.

"Lamarck was, moreover, regarded as a visionary because he believed in the possibility of forecasting the weather from observations of the atmosphere and of the forms of clouds, and yet who would now blame him for his hopes?

"Lamarck was a man of genius who foresaw the advances of science on many sides, but who did not possess the faculty of being able to present his ideas in a felicitous form intelligible to his contemporaries."

The lecturer then returned to his theme, that experimental research in zoology is the need of the hour, and proceeded to give some striking examples of the results to which it has led.

Firstly, he described the alternation of generations in the gall-producing insect, whose two forms were originally known as Biorhiza and Teras. The Biorhiza, a wingless and asexual form, is born from eggs laid in the roots of the oak; it crawls up to the branches, and there causes the gall excrescence as it lays its unfertilized eggs. From these eggs issue the sexual winged form Teras, which conjugate; and the female then lays her eggs in the roots of the oak, and from these spring the Biorhizæ.

He then spoke of the strange metamorphoses of a certain insect *Sitaris*, semi-parasitic on a species of bee, *Anthophora*, which have been investigated by M. J. H. Fabre, and of those of the lobster. In all these cases, forms supposed to have been different have proved to belong to the life-history of one and the same animal.

"It is because zoology is at this moment at a critical period, and because of the positive nature of the affirmations made by the partisans of transformism, that the methods of the science must be modified, and that besides simply registering the existence of species, we must have constant recourse to the test of experiment. Such is the conclusion at which we logically arrive, and which to-day, I repeat, has become imperative.

"I have sought to point out to you the considerable part which our country has played in the progress of the natural history of man and of animals during the century which is drawing to a close.

"I should have wished to speak also of the origin and development of other branches of biology, of comparative and general anatomy, of experimental physiology, anthropology, and palæontology. But I think I have said enough to show that I am justified in spurning the reproaches and inimical accusations so often made against us, that France is a country in which scientific work is on the decline, and whose decadence is at hand.

"We open our meeting full of joy in the present, of hope for the future, in presence of the imposing spectacle whose success has but increased since it began in May, and which demonstrates the inanity of these accusations. Let your labours, varied as they are important, prove once more, during a year so fertile in pacific manifestations, that we work only for the restoration of our country, and that the peace of which others speak much, and perhaps believe in but little, is the sole preoccupation of all men of sense, of all who are in earnest in this country of France—France whose desire is to remain free and independent, ever animated by the most generous and patriotic sentiments."

At the conclusion of M. Lacaze Duthiers' speech, which was most enthusiastically cheered, the Treasurer announced that the receipts for the year had been £3760, the expenses £3480, and that the total capital of the Association amounted to £33,060. An important legacy of about £7000 had been bequeathed to the Association by M. Girard, for the promotion of researches on prehistoric man.

The proceedings concluded with a report on last year's meeting at Oran, and the members then adjourned to the École des Ponts et Chaussées, where the Sectional sittings took place.

The French Association is subdivided into seventeen Sections and sub-Sections: (1 and 2) Mathematics and Astronomy; (3 and 4) Civil and Military Engineering and Navigation; (5) Physics; (6) Chemistry; (7) Meteorology; (8) Geology and Mineralogy; (9) Botany; (10) Zoology, Anatomy, and Physiology; (11) Anthropology; (12) Medical Science; (13) Agriculture; (14) Geography; (15) Political Economy; (16) Pedagogy; (17) Hygiene.

An immense number of papers were contributed to the

Sections. We may mention:—(Sections 1 and 2), M. Joukowski, on an apparatus for determining moments of inertia. (3 and 4) M. Pichou, on a universal paddle-wheel; by altering the direction of the paddles, a steamer may be reversed without reversing the engines. (5) MM. Baille and Féret, on a method for reading the oscillations of the balance with great precision; the authors employ a very simple optical arrangement, which allows them to estimate the 1/2000th part of a milligram by the displacement of a series of Newton's rings. (6) MM. Alexeieff and Werner, on the heat of neutralization of certain aromatic compounds; the authors show that the general results already acquired enable one to determine in certain cases the position of disubstituted compounds. Messrs. Gladstone and Perkin, on the relation between constants of refraction, dispersion, and magnetic rotation in organic compounds. M. Cazeneuve, on camphor derivatives. M. Franchimont, on the action of nitric acid on organic bodies according to their function. M. C. Chabrié, on the synthesis of selenium organic compounds. M. Raoult, on a new form of the apparatus for cryoscopic observations; the author produces cold by the evaporation of carbon disulphide. M. Meunier, on insoluble crystalline compounds of mannite and sorbite, with the aldehydes, serving to isolate these bodies from organic mixtures (the juice of fruit, &c.). M. Berlinerblau, on a sweet body, $NH_2 . CO . NH . C_6H_4 . OC_2H_5$. M. Istrati, on new general methods for the synthesis of aromatic compounds. (7) M. Crova, on the standardization of actinometers. M. D'Abbadie, on the qobar. M. Angot, on the representation of the variation of temperature by a harmonic formula. (8) M. Szabo, on the opal mines of Hungary. M. Malaise, on the Belgian Olethamias. M. Bleicher, on the glacial formation of the Vosges. (9) M. Timiriazeff, on the *rôle* of light-intensity in the assimilation of carbon by plants. M. Mer, on variations of structure in the wood of pines. M. Clos, on certain cases of hybridity in plants, and on the vegetation of *Marchantia polymorpha*. (10) M. de Lacaze Duthiers, on the fusion of nerves and ganglia in Mollusca, and on the interpretation of the membrane which separates them. M. Beauregard, on the Cetacean ear. M. Packard, on the distribution of the organs of taste in insects. M. Sirodot, on the dentition of elephants. M. Jourdain, on the necessity of conjugation for the continued propagation of Protozoa. M. de Varigny, on the action of certain convulsive poisons on *Carcinus mœnas*. (11) M. A. Bertillon, on the anthropometric characteristics of the French nation classed by the departments. M. V. Schmidt, on the Stone Age and the prehistoric Iron Age in Denmark. M. de Mortillet, on right- and left-handed individuals in prehistoric times. M. Manouvrier, on anthropometric researches on natives of Algeria. Dr. Maurel, on the relation of the section of the thorax to the height and the length of the foot. (12) M. Massé, an instrument for determining the position of the fissure of Orlando. M. Steinhaus, on the causes of suppuration. M. Jolly, on the use of iodine in tuberculosis. M. Luys, on the pathological anatomy of madness, and on the action of rotating mirrors on the nervous system. M. Michel, on the influence of drinking-water on public health. (13) M. Kunckel, on the destruction of locusts in Algeria. M. Ladureau, on a rapid method of colorimetrical analysis for nitrates. M. Dehérain, on the loss and gain of nitrogen in arable lands and on the graphic representation of crops. (14) M. Castonet des Fossés, on the future of the Negro race. M. Gauthiot, on a route for mining exploration from Bangkok to Korat. The Prince of Monaco, on dragging in deep water. M. de Guerne, on an exploration of the Forno de Graciosa (Azores). (15) M. Arthur Raffalovich, on economic legislation in England in 1888. M. Martineau, on the true motives for the introduction of free trade into England. M. Ch. Grad, on insurance against old age and infirmity in Germany. (16) M. Frederic Passy, on a system of writing which permits blind people to communicate with the non-blind; M. Paul Passy, on spelling reform; M. Herzen (of Lausanne), on the organization of certain secondary schools to enable them to continue the teaching of the primary schools. M. Morel, on the organization of the *enseignement spécial* in the secondary schools of Paris. (17) M. Delthil, on diphtheria and its treatment. M. Teissier, on diphtheria at Lyons. MM. Dubief and Brutel, new experiments on the value of sulphurous acid as a disinfectant.

The work of the Sections was most usefully supplemented by visits to different institutions and to the Exhibition. Sections 1 and 2 inspected the collection of calculating machines at the Conservatoire des Arts et Métiers, under the guidance of M. Ed. Lucas. Sections 3 and 4 examined the new steerable balloons with the inventor, Commandant Renard, while various other parts of the exhibition of the Minister of War were explained by officers of the special departments. Section 6 inspected the fine collection of chemical products at the Champ de Mars (Class 45), general explanations being given by MM. de Clermont, Riche, Suilliot, Billault, Istrati, and others. M. Tanret showed his interesting exhibit, including specimens of pelletierine, the alkaloid of the pomegranate bark now so extensively used as a tænifuge, and ergotine, the active principle of ergot of rye, by whose discovery M. Tanret has rendered such signal service to therapeutics; and last, but not least, M. Grimaux, Professor at the École Polytechnique, gave an account of the fine exhibition of Lavoisier's papers and instruments, which he had selected from the collection of M. de Chazelles, to whom they belong,[1] and pointed out the portrait of M. and Mme. Lavoisier, by David, in the Palais des Beaux Arts. Section 7 met at the Exhibition to see the instruments which record the direction and the vertical and horizontal components of the wind on the top of the Eiffel Tower, the results being transmitted electrically to the Palais des Arts Libéraux, and inscribed on MM. Richard's revolving drums. The Section also met at the Central Meteorological Office to see experiments on cyclones by M. Weyher. Sections 8, 9, and 10 inspected the fine galleries at the Museum, which have just been opened.

Other scientific visits were paid to the Institut Pasteur, the sewers of Paris, and to various glass-works, gas-works, &c. On Thursday, August 8, the Municipality of Paris threw open their magnificent suite of rooms at the Hôtel de Ville to the members of the French Association; while extraordinary animation was lent to the scene by the presence of the students of Paris and their foreign comrades, 8000 guests in all having been invited. On the following evening, the Association was received by M. Yves Guyot, the Minister of Public Works, and Mme. Guyot at the Ministry in the Boulevard St. Germain. A concert was given during the evening by members of the Opéra Comique; while the gardens lighted up by Chinese lanterns afforded a pleasant change from the crowded *salons*.

On Sunday, August 11, an excursion was made to St. Germain-en-Laye, and to Meudon, dinner being served in the orangery which belongs to the beautiful grounds of the Astronomical Observatory, directed by M. Janssen. M. Janssen offered a warm welcome to the members, and said that he should be very willing to let his Observatory be used for the scientific purposes of the Association. On Monday, August 12, a lecture was delivered by General Tcheng-Ki-Tong, on the social economy of China. On Wednesday, August 14, the Association offered a banquet to its foreign members at the Restaurant d'Alsace-Lorraine on the first story of the Tour Eiffel.

M. de Lacaze Duthiers made a short speech, in which he declared that he would not say good-bye to the foreign guests, but *au revoir*, as he hoped to see them all again

[1] M. Grimaux has published this year a remarkable monograph on Lavoisier (Félix Alcan).

at the meeting of the Association next year at Limoges. That they did not forget past events was proved by the name of the restaurant in which they met, but he firmly believed that "*Le temps prime la force*," and he drank "to the peace of the whole world."

MM. van Beneden, Dekterev, Istrati, Hartog, Ramon de Luna, Llaurado, Stephanos, Timiriazeff, and Watson, spoke in the name of their respective countries, and drank to the cause of peace and to the prosperity of France.

On Friday, August 16, a general excursion took place to the paper works at Essonne, and to the works of M. Decauville (the constructors of the narrow-gauge railway in the Exhibition), who offered a lunch to their guests.

Thus concluded this brilliant and successful session of the French Association.

All foreigners must have carried away with them a pleasant memory of their welcome. Special thanks are due to Prof. Gariel, the Secretary of the Association, and to the Vice-Secretary, Dr. Cartaz, for the remarkable kindness and courtesy they showed to the foreign guests.

EXPERIMENTS ON ELECTRO-MAGNETIC RADIATION, INCLUDING SOME ON THE PHASE OF SECONDARY WAVES.

IN continuation of some experiments which were described in NATURE, vol. xxxix. p. 391 ("Repetition of Hertz's Experiments and Determination of the Direction of the Vibration of Light") attempts were made to obtain periodic reflection of electric radiation from plates of different thicknesses, analogous to Newton's rings, with the view of further identifying these radiations with "light."

It was there described how a sheet of window-glass refused to reflect the Hertzian waves, but how a masonry wall reflected them readily. The non-reflection from the thin sheet is due to the interference of the reflected waves from each side which takes place owing to a change of phase of half a period on reflection at the second surface, as in the black spot of Newton's rings.

By making the reflecting plate such a thickness that the reflection from the back has to travel half a wave-length further than that from the front, the two reflections ought to be in accordance, for they differ by a whole period, half arising from difference in path, and half from change of phase on reflection; but if the difference in paths were made a whole wave-length by doubling the thickness of the plate, there ought again to be interference, and so on.

The first plan tried with this end in view, was to fill a large wooden tank to different depths with water or other liquids. On gradually filling the tank reflection should be obtained, and at a certain depth equal to $1/4\,(\lambda \sec r)/\mu$, reach a maximum; further addition of the liquid then should diminish the reflection, and at double the above depth the reflection should reach a minimum, the two waves interfering.

The mirrors for concentrating the radiation had for this purpose to be suspended over the tank as shown in the figure. The tank was first tried empty, but unfortunately the wooden bottom was found to reflect, thus it was useless for the purpose intended. I then tried what ought to have been tried before constructing the tank—namely, whether ordinary boards, such as flooring, reflected. The floor was found to reflect readily. This was attributed to moisture in the wood causing it to conduct, specially as wood was found not to polarize by reflection. Experiments were then undertaken to determine if water reflected, even though in thin sheets. A large glass window was placed beneath the mirrors and flooded with water; this was found to reflect well, both when the mirrors were in the position shown and when rotated to the position "at right angles." Thus water also acts like a metal, reflecting the radiation however polarized. The glass had to be hardly more than damp in order to get some reflection.

The wooden tank being unsuitable, a glass tank was thought of, but was given up for solid paraffin, which, being in slabs, could be easily built up into a vertical wall of any desired thickness. Through the kindness of Mr. Rathborne a large quantity of this was lent for the purpose.

A thin sheet of paraffin about 2 centimetres thick was found not to reflect, as was expected. Next a wall 13 centimetres thick (180 centimetres long, 120 centimetres high) was tried, and found to reflect, this being the thickness required in order to add another half period to the retardation of the wave reflected from the back at an incident angle of 55°, the wave-length being taken as 66 centimetres, and the index of refraction being taken as 1·51, the square root of 2·29, the value taken as the specific inductive capacity of paraffin.

Then a wall twice the thickness was tried, but it also reflected, contrary to expectation. While in doubt as to the cause of this, it was decided to make a determination by direct experiment of the index of refraction of paraffin for these waves, by a method suggested in NATURE (vol. xxxix. p. 393), which consists in interposing a sheet or wall of paraffin between the resonator and the metallic reflection in the Hertzian experiment of loops and nodes which are formed by the interference of the reflected wave with the direct radiation; the ratio of the velocity in the wall to that in the air being easily found from the observed shifting of the loops and nodes towards the screen.

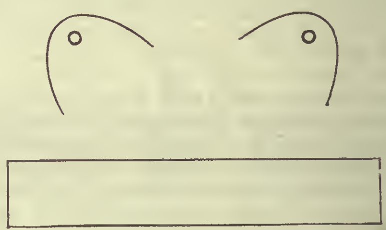


FIG. 1.

In this way the index of refraction for the radiation of the period employed was found to be about 1·8, so that the paraffin walls which had been used were too thick; The proper thickness being about 10 and 20 centimetres—exactly so for an incident angle of 51°. On making this alteration I fancied I could detect a slight difference between the reflections from the thick and thinner walls; still the difference was not sufficient to be at all satisfactory. The nature of the observing apparatus makes it almost impossible to say if the reflection on one occasion is more intense or less so than on another so long as sparks can be obtained. This is due to the sparking-point in the receiving apparatus continually requiring readjustment when working with small sparks, as the distance between them changes either from shaking or from the points getting burnt up. Dust and moisture from the observer's breath are also troublesome.[1] Thus it might be quite possible that the points had always to be much closer with the 20 centimetre wall than with the 10 centimetre wall in order to get sparks, and yet the difference escape detection; the thing observed being whether sparks can be obtained or not, the eye being incapable of comparing with any degree of accuracy the intensity of light on one occasion with that on another.

However, if it had been possible to suddenly change the wall, while viewing the sparking, from being 10 to 20 centimetres, it would have been easy to detect any

[1] With *very small* sparks the thermal expansion must be counteracted by unscrewing.

difference which might have existed, but unfortunately it took some little time to alter the wall.

In order to obviate this difficulty the following device was resorted to with the object of showing that there was a difference in the behaviour of the wall when 10 centimetres thick to its behaviour when 20 centimetres thick. (For at the time I did not see that the experiment was inconclusive, the effects observed being the same whether the back reflected at all or not). A *small* sheet of zinc was placed at the back of the wall, and the effect on the sparking observed while an attendant suddenly removed or again replaced the zinc. It was supposed that when the wall was 20 centimetres thick and there was sparking, that on suddenly placing the zinc on the back the sparking would increase, owing to the phase of the reflection from the back being half a period different from that of the reflection from the zinc; but when the wall was 10 centimetres thick that the presence of the zinc would diminish the sparking.

It was with no little surprise that the reverse was observed. That is to say, placing a sheet of zinc about 30 centimetres square on the back of the wall actually aided the reflection from the back so as to diminish the sparking with the 20 centimetre wall, but increasing it with the 10 centimetre wall. This observation made it look as if it must be on the first reflection from the paraffin—that is to say, on passing from a rare to a dense medium—that the "change of phase" occurs, and not at the back,—at a reflection from a dense to a rare medium, as is ordinarily supposed. For Hertz's experiment of loops and nodes showed that there was no change of phase on metallic reflection—that is, of the *magnetic* displacement. There is a change of phase of the *electric* displacement. It is important to bear in mind that the electric loop and the magnetic node occurred at the same place, and of course so too the electric node and the magnetic loop.

In order to investigate this, attempts were made to obtain Hertz's loops and nodes off a paraffin wall as reflector, but no reflection could be discovered, the intensity of the vertically reflected rays being insufficient. However, by inclining the incident radiation to an angle of 57°, the intensity of the reflection was found to be amply sufficient. With a circular resonator, which is for these

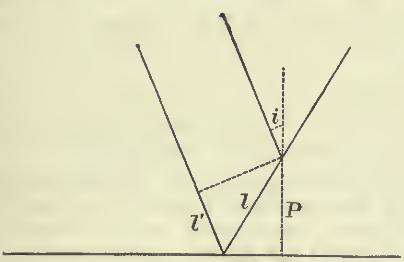


Fig. 2.

waves about 10 centimetres in diameter, sparks were obtained close to the reflector, the circle being held at right angles to the wall so as to be equally inclined to both direct and reflected radiation, and this was confirmed by a straight resonator giving none there. At 30 centimetres from the wall [1] there was interference with the circle, and vigorous sparking with the straight resonator. This being about the right distance for the loop to be from the reflector at an incident angle of 57°,

$$\frac{\lambda}{2} = l + l' = p \sec i(1 + \cos 2i) = 2p \cos i.$$

Thus there is no doubt that it is on the second reflection that the change of phase occurs.

Here, then, was a difficulty—the small sheet of zinc at the back of the paraffin undoubtedly reflected with a change of phase, while, according to the Hertzian experiment, metallic reflection is unaccompanied by change of phase. On mentioning this to Prof. Fitzgerald, he pointed out to me its complete agreement with wave theory. For by considering the secondary waves produced by dividing up a primary wave with reference to any point into half-period zones, it can be seen that the effect of the primary is equivalent to half of that arising from the central circle, and in consequence is half a period behind the phase which would be at the point if an infinitesimal portion of the centre alone acted. For the effect of each ring can be considered as destroyed by half the effect of its two

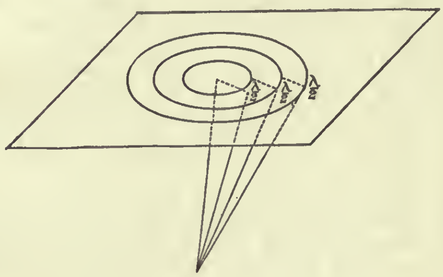


Fig. 3.

neighbours, and thus half the effect of the central circle is left uncompensated. But the distance of the edge of this circle is half a wave-length further from the point than its centre is, so that the resultant phase at the point will be behind that due to the centre, but in front of that due to the edge, which effect would be half a period behind that arising from the centre. Taking the mean between them, the resultant phase then at the point is a *quarter* [1] of a period behind what it would be if the centre alone acted. Thus it was that the reflection from the *small* sheet of zinc differed from what I had expected it to be.

Experiment showing Phase of Secondary Waves.—To experimentally test this, the small sheet of zinc was used as reflector in the Hertzian experiment of loops and nodes. Employing the circular resonator, the position of interference was found to have shifted out from 17 to over 24 centimetres, which nearly corresponds to an acceleration of phase of a quarter of a period, the wave going in all nearly a quarter of a wave-length further, and nevertheless being still only half a period behind the phase on starting. The furthest out the loop could be is 25·5 centimetres: to obtain this would require an indefinitely small reflector. Of course, when the resonator was close in to the sheet, no change of phase was found to occur, the sheet being then practically infinite.

Another interesting observation was made. A *long* sheet of zinc 30 centimetres wide was found to act similarly to the sheet 30 centimetres square, provided it was placed with its breadth parallel to the electric displacement. When thus placed at 24 centimetres from the circular "resonator," there was interference, but on rotating the reflector so as its length was parallel to the electric displacement, sparking occurred, and now the "resonator" had to be brought back to 17 centimetres in order to again obtain interference. This experiment is interesting in connection with the electro-magnetic way of looking at the acceleration of phase as being due to the accumulations of electricity on the edges of the reflector, which is the same as the reason why it is necessary to use *long* cylindrical mirrors, as was pointed out by Prof. Hertz in a letter last February to Prof. Fitzgerald. This experiment is really the same as Stokes's *experimentum crucis*, as Prof. Fitzgerald points out.

If, instead of using the whole primary wave in the

[1] It would occur at about 17 centimetres on vertical reflection. This experiment was also tried with a metallic reflector.

[1] That it aided the back rather than the front was probably due to their phase not being an exact period or half period different from each other.

former experiment, it be passed through a screen with a hole in it (either square or a long slit at right angles to the electric displacement), the position of interference, as might be anticipated, was not shifted out as much as before. In the rough experiment made, it was found to occur at about 19 centimetres from the screen.

It was now thought well to repeat the determination of the index of refraction with a larger wall and metallic reflector than had been used before, as this change of phase might have affected the former results. But it was found that it had not done so to a sensible extent. However, the result of these new experiments was finally to give for paraffin, $\mu = 1·75$, and at the same time it was found that the wave-length given by the "vibrator" was 68 and not 66 centimetres, as had been assumed.

Two new knobs for the "vibrator" had been made, and the fact had been overlooked that they were slightly larger than the old ones, which gave a wave-length of 66 centimetres. These new knobs were electro-plated with gold, and were a great saving of trouble, as they could be cleaned by merely rubbing with paper; apparently, the gold which was carried across by the sparking in the form of a black powder coming off, but some may have reburnished on. It was a curious thing that, if the knobs were left uncleaned over-night, the next morning it was very hard to get the black off, some molecular change probably occurring.

If the value of μ thus found be not in some way due to the paraffin being in separate blocks, it would show a remarkable anomalous dispersion for paraffin near these curiously slow vibrations, and, as suggested by Prof. Fitzgerald, may be connected with the vibration periods of atoms in the molecule, as it can hardly be connected with the vibrations in the atoms themselves. It might be interesting to investigate whether these slow vibrations could cause dissociation, and thus lead to a photographic method of observing them. It may also be allied with ordinary electrolysis by very long period currents, as is also suggested by Prof. Fitzgerald.

Assuming $\mu=1·75$,[1] and $\lambda=68$ centimetres, the thicknesses of the walls in the "Newton's ring" experiment, as above described, were wrong. However, it was found more convenient to alter the angle of incidence to suit the walls than to change the thickness of the walls. Thus, the mirrors were put at 25°, which is the proper angle with the above data for 10 centimetre and 20 centimetre walls. On now repeating the experiment, better results were obtained than I should have anticipated. When the wall was 10 centimetres thick, continuous sparking was easily obtained, but, when 20 centimetres thick, it was only after much adjustment and patience that perhaps one slight spark could be obtained. This was quite sufficient, considering the nature of the wall, for it was only built up of plates, which afforded internal reflections, weakening the transmitted rays, and also since it requires the sum of the effects arising from the multiple reflections back and forward inside the wall to completely interfere with the front, and some of these are lost at the edge of the beam.

FRED. T. TROUTON.

ICE GROWTH.[2]

SEVERAL of the Arctic Expeditions have instituted observations on the rate of growth of the ice during the winter, and in the "Contributions to Arctic Meteorology," vol. i., 1885, records of this nature are given for the following stations: Gulf of Boothia, Assistance Bay, Port Bowen, Walker Bay, Cambridge Bay, Camden Bay, Princess Royal Islands, and Mercy Bay. The second German Arctic Expedition has also undertaken such investigations and published results in its report (Leipzig, 1874).

In the present paper these observations are compared with the results of the theory of ice-formation, the basis of which has been explained by the author in a paper on some points in the theory of the conduction of heat.

The theory gives for the thickness (λ) of ice formed in the time (t) the following formula, which is approximately correct—

$$\lambda^2\left(1 + \frac{cb}{3\lambda}\right) = \frac{2kT}{\lambda\sigma}.$$

In this formula (c) is the specific and (λ) the latent heat of ice; (k) is the coefficient of conduction, (σ) is specific gravity, (f) is the temperature at the surface of the ice at the time (t), (k) the sum of cold for the same time; the last is the sum of the temperatures counted downwards from 0° C., from the commencement of ice formation up to the time (t).

The squares of the measured ice-thicknesses were taken and multiplied by the factor contained in the above formula, and the differences between the successive values were divided by the sums of cold for the corresponding intervals of time. The quotients for the different observations of each station differ in some degree from each other. Those which are most regular are the Gulf of Boothia, Assistance Bay, Port Bowen, and the German Expedition. The mean values for these four stations are, respectively, 0·877, 0·851, 0·869, and 0·878. Of the stations which show considerable differences, Walker Bay gives 0·919, Cambridge Bay 0·780, Camden Bay 0·791. The smallest quotients are, 0·755 for Princess Royal Islands, and 0·700 for Mercy Bay in the first winter, whilst it is 0·810 for the second winter.

We may take 0·87 as the normal value of the quotient. If any station gives considerably less than this, it may be concluded that some disturbance of the process of ice formation has occurred, such as, *e.g.*, if the station was affected by a warm current which brought up warmer water, and so delayed the formation of the ice.

The units for the figure 0·87 are the Fahrenheit degree, the English inch, and the day. For Celsius, centimetres, and the day, the figure would be 10·092. From it the coefficient of conduction of Polar ice, k, is 362·4. If the second be taken as the unit of time, the value of k would be 0·0042.

DR. C. FORSYTH MAJOR'S DISCOVERIES IN THE ISLE OF SAMOS.

WE are glad to learn that Dr. H. Woodward, who has just returned from Florence, has secured for the Palæontological Department of the British Museum (Natural History) the valuable collection of Vertebrate remains of Lower Pliocene age obtained by Dr. C. Forsyth Major during the year 1887 in the island of Samos, in the Turkish Archipelago. Dr. Forsyth Major lately contributed to the *Comptes rendus* (vol. cvii. pp. 1178–81) a preliminary notice of this collection. Among the remains are a large number of forms specifically identical with the mammals from the equivalent deposits of Pikermi in Attica, Baltavar in Hungary, and Maragha in Persia; but there are also some new types, which are of interest either from a distributional or a purely zoological point of view. Among these new forms is a species of ant-bear (*Orycteropus*), which is the only representative of that genus yet known beyond the Ethiopian region. A large pangolin, which is estimated to have been nearly three times the size of the West African *Manis gigantea*, is made the type of the new genus *Palæomanis*; and is of interest as showing how the African pangolins may have been connected with those of India. Perhaps the most striking new

[1] This value agrees with polarization experiments. No reflection was obtained at its corresponding angle, while at $\tan^{-1} 1·51$ some sparks were occasionally seen.

[2] Abstract of Dr. Stefan's paper, "Ueber die Theorie der Eisbildung, insbesondere über die Eisbildung im Pola-Meere," from the *Sitzungsberichte* of the Vienna Academy.

type is a large ruminant, referred by the author to the *Giraffidæ*, and stated to connect *Helladotherium* and the giraffe with some of the aberrant antelopes of Pikermi. Finally, a large ostrich is especially noteworthy from a distributional point of view, since we now have remains of this genus from Samos, the Thracian Chersonese, and Northern India.

NOTES.

WE regret to have to record the death of the eminent American physicist, Prof. Elias Loomis. He was born at Wellington, Connecticut, in 1811, and was educated at Yale College, where he acted for some time as tutor. He was successively Professor of Mathematics and Natural Philosophy in Western Reserve College, Ohio; Professor of Natural Philosophy in the University of the City of New York; and Professor of Natural Philosophy and Astronomy in Yale College. The latter appointment he received in 1860, and he held it until his death. Prof. Loomis was the author of more than 100 scientific treatises. Among his works was a series of text-books on mathematics, natural philosophy, astronomy, and meteorology. Of this series more than 500,000 copies were sold. During the last twenty-five years of his life he devoted himself chiefly to original research, and gave much time and energy to the preparation of a full account of the principles of meteorology. He was a member of various American and European scientific Societies.

ON August 19 the fiftieth anniversary of the foundation of the Observatory at Pulkowa was celebrated. Among those present on the occasion were the President of the St. Petersburg Academy of Science, the Grand Duke Constantine Constantinovitch, the Russian Ministers and Court dignitaries, the German and French Ambassadors at the Russian Court, and deputations from the Universities and Academies of Russia, and from foreign observatories, including Greenwich and the chief German observatories. Numerous congratulatory telegrams were received. The Czar expressed in a telegram high appreciation of the scientific merits of the Observatory.

THIS week the meeting of the Photographic Convention of the United Kingdom is being held in London. It was opened on Monday in St. James's Hall, where an interesting collection of photographic appliances and specimens of the best photographic work had been brought together. In his inaugural address, Mr. Andrew Pringle, the President, reminded his hearers that the present year was the fiftieth of practical photography, and traced the history of the art from its birth to its jubilee.

AT the meeting of the Linnean Society of New South Wales on June 26, Dr. Oscar Katz read a paper giving an account of experimental researches with the microbes of chicken-cholera. In this paper the author describes the investigations undertaken by him since last year with regard to the microbes of chicken-cholera. The larger portion of the experiments were made on wild rabbits; in addition, the action of the microbes on domestic poultry, as well as on indigenous birds, on hares, guinea-pigs, and ferrets was studied. A number of other points in the life-history of the chicken-cholera bacteria are dealt with in the paper: for instance, their behaviour when transmitted through the bodies of rabbits in successive generations; towards desiccation, putrefaction, &c. Rabbits were repeatedly protected against a virulent infection, in consequence of having previously partaken, at intervals, of cultures of the microbes in which the latter had been killed by moderate heat.

ON August 17, at 1 o'clock a.m., a severe earthquake shock of an undulatory character, lasting six seconds, was felt at Jablanica, Bosnia. The direction of the seismic wave was from south-east to north-west. According to a telegram from Mostar, a shock, lasting ten seconds, was felt there also on August 17. Some damage was caused to the railway line between Mostar and Ostrojac, while at Konjica a wall collapsed. The duration of the shock at the latter town was only five seconds.

THE Pilot Chart of the North Atlantic Ocean for the month of August shows that fine weather prevailed generally over the greater part of the North Atlantic during July. The only storms worthy of notice were two which prevailed in the western part of that ocean; the first was situated in latitude 40° N., longitude 58° W., on the 10th, and moved across Newfoundland on the 16th; the next day it was joined by the second storm, which passed out to sea from the coast of New Jersey on the 15th. The storm then travelled about north-north-east, and disappeared off the south coast of Greenland. Much fog has been experienced along the Transatlantic routes, and icebergs have been numerous, within the usual limits.

THE Report of the Meteorological Commission of the Cape of Good Hope for the year 1888 contains monthly summaries and results for 38 stations and rainfall statistics at 292 stations, including returns from Basutoland, Orange Free State, &c. In addition to the tables, there are some extremely interesting diagrams showing the actual rainfall in 1888 at a number of stations throughout the colony, as compared with the average rainfall. They show that in nearly all months the fall in 1888 was much above the average. Storm warnings are not yet issued, but weather telegrams are received from a number of stations, and after correction and collation, reports are sent to coast stations and entered on charts, for the information of seamen and others.

VOLS. IX. AND X. of *Aus dem Archiv der Deutschen Seewarte* contain reports of the activity of that institution during the years 1886 and 1887. The collection of observations at sea, and at distant stations, has been carried on with vigour, while weather telegraphy and the verification of chronometers and nautical instruments also receive great attention. Dr. Neumayer regrets that the ever-increasing routine work curtails the time for scientific investigation, yet the volumes contain many valuable researches by members of the staff, to some of which we can only very briefly refer, although all are worthy of careful study. In vol. ix. Dr. van Bebber, dealing with typical weather-conditions, investigates the passage of barometric depressions over Europe during the years 1881–85, in continuation of a former paper referring to 1876–80. The object of the discussion is to trace the influence of the depressions upon the weather, with a view to the discovery of the laws of the changes of direction of their tracks, and of their rates of progression. The author shows that the depressions move along certain tracks with greater velocity than the motion of minima generally. The text is illustrated by twenty plates. The other articles are: on the determination of the refraction constants; and remarks from ships' logs relating to weather, &c., in Eastern Asiatic waters. In vol. x. Dr. Köppen contributes a useful paper on the determination of air-temperature. The author investigates the influence of radiation on different thermometers and screens, and gives a *résumé* of the experiments with regard to the latter in various countries, and of the observations on local differences of temperature (including the influence of radiation). These experiments seem to show that screens through which the air can freely pass are better than large shelters, and that the effect of radiation is lessened by the free circulation of the air, and by the smallness of the thermometer-bulbs. M. Möller contributes an article on the circulation of the atmosphere between the equator and the Poles. The results arrived at differ from those of Prof. Ferrel, especially with regard to the force of westerly winds in latitude 38°, in the lower and upper strata. The volume concludes with an article on Combe's apparatus for testing chronometers.

FROM the statistics of the Education Department in India during the past year, it appears that the percentage of those of school-going age who actually attended was 11·8 as compared with 10·7 the preceding year. The total attendance increased about 120,000 on the preceding year, but the numbers at the training-schools fell from 5716 to 4761. Year by year the Mahometan pupils have increased, and during the past year their numbers were 804, 485 as against 752,441 in 1886–87. The total expenditure on education has increased from 2,52,41,414 rupees in 1886–87 to 2,61,91,280 rupees in 1887–88; but the indirect expenses—that is, the cost of inspection, buildings, scholarships, &c.—fell from 54,11,098 rupees in 1886–87 to 52,81,471 in 1887–88. The fees increased from 65,29,958 rupees to 72,94,023 rupees. Except in the circumstance that the numbers attending the training-schools have declined very much, the Government thinks that everywhere marks of great progress are shown. The expenditure by local bodies on education has also increased from 37,14,579 rupees in 1886–87 to 46,41,551 rupees in 1887–88.

A SWEDISH paper gives an account of some experiments made by Captain R. von Mühlenfels in Carlskrona in storing live fish, his object being to discover the maximum degree of confinement they could bear without deteriorating in quality. With this aim he placed 1300 kilogrammes of live cod in a cask, covered within and without with asphalt tar, and of about 52 cubic metres in content. The cask was firmly fixed in a stream of fresh running water. During the first few weeks of their confinement the fish grew thinner, and had deteriorated in quality. At the end of six weeks, however, it was found that those which remained had much improved by their captivity.

THE French *Journal Officiel* recently contained a report which Prof. Edmond Perrier had sent in to the French Government on the subject of the best means of protecting fishermen against porpoises. Although the depredations of these creatures have been exaggerated, it is certain that they do considerable damage, especially on the Mediterranean coasts of France, by tearing the nets. For at least a quarter of a century past, efforts have been made to lessen the numbers of the porpoises by offering a reward per head, and by other remedies. In 1865 the Government invited the fishermen themselves to organize a seine-net fishery for porpoises, and they were offered special nets, and sums of from 5 to 25 francs for each animal. It was, however, found in practice that as soon as the porpoises felt themselves to be surrounded, they simply jumped over the seine-nets and were at large again. Some years later the fishermen of Cannes, Saint Tropey, and La Ciotat petitioned Government to lend them a gun-boat, filled with torpedoes, for the purpose of firing at the porpoises. This was done, and the cannon and the torpedoes scared away the porpoises for about eight days, but they scared away the fish as well, so that there was no fishing for at least a week. The porpoises, moreover, are too numerous and too agile to be shot, one by one, in an effective manner. The report sums up that the employment of artillery against porpoises is perfectly useless, that a reward for killing them singly is equally unavailing, and that the only thing to do is to encourage the fishermen to unite in chasing the porpoises, and in forming a mutual insurance guarantee against their depredations. In the meantime the Department of the Marine might continue to indemnify, to a certain extent, the proprietors of any nets that have been very seriously injured.

A FRUITFUL study may be made of the sociology of small sections of a community. M. Dumont finds in the rural communes of France much individuality as regards density, wealth, mobility, birth, marriage, and death rates, &c. We will give a few facts from his interesting paper (*Rev. Scient.*). Unlike what usually occurs near large towns, the eleven rural communes in the outskirts of Caen are with one exception (Mondeville) being depopulated. Great mobility in the rural populations is generally associated with a low birth rate, great fixity with a high one. Examples of a low birth rate occur in the communes near Caen (13 to 17); on the other hand, the natality is high in some of the poor and miserable communes of the Côtes-du-Nord (40 to 41). Side by side in the same department, and even the same canton, are very different birth rates. For the nine communes of Paimpol (Côtes-du-Nord), some 20,000 inhabitants, the rate varies from 20 to over 30. In Bretagne, with a generally high birth rate, there are isolated communes with a very low one; and two communes are cited, which are apparently much alike, and where subsistence is drawn from the sea, but the birth rate of one is 35·1, that of the other 21·7. In the canton of Isigny (Calvados) the birth rate was in general steadily low throughout the century till ten or twenty years ago, when there was a remarkable rise. The marriage rate in Ile-de-Ré is considerably above the average for France, while the fecundity of marriage has of late been going down. But one commune, the small town of Saint Martin, shows a recent decline of its marriage rate (25 per cent. in three decades) while the constancy of its low birth rate points to an increased fecundity of marriage. The death rate in many communes (those of Douvres, *e.g.*) is now much greater than early in the century. The increase of illegitimacy and high mortality of infants are often obviously the cause of a rising death rate.

CONSIDERING the progress of biology, Dr. Düsing remarks (in a recent number of *Humboldt*) that for 25 years the effort of zoology has been mainly to determine the descent of animals by means of their morphological features. The flourishing of morphology has been favoured by the discovery of a large number of lower forms of animal life. But the time is not far off when it will become more and more difficult to discover new animals, and those known will have been efficiently described. Investigation will therefore be directed more to the mode of life, which, in the case of most animals, is but little known. This demands long observation and a special talent of observation, which is quite different from that required by morphology. Several investigators have entered this sphere, studying especially the higher animals; but most continue in the direction impressed on zoology by Darwin. The prevailing tendency is exemplified in the founding of a Professorship of Phylogeny at Jena. And it is a remarkable fact that the present occupant, Prof. A. Lang, is one of those who are leaving the older paths for biology, as shown by his recent work, which is entitled "On the influence of a fixed mode of life on animals, and on the origin of non-sexual propagation through fission and budding."

THE *Kew Bulletin* for August consists of a full account of the fluted scale-insect (*Icerya purchasi*, Maskell), which is described as one of the most destructive pests injurious to plants. Of late years it has made its appearance in South Africa, New Zealand, and California. The best account of the insect has been published by Prof. Riley, and the results of his inquiries are made easily accessible in the *Bulletin* to a wide circle of readers.

MR. WRAY, Curator of the Museum of Perak, in the Malay Peninsula, communicates to the *Perak Government Gazette* a note on the mango weevil, a pest which has lately excited some alarm in various parts of the East. Mr. Wray describes it as a small beetle infesting the mangoes in Perak, particularly the introduced varieties, which has been examined and found to be identical with the mango weevil of India, known to science as *Cryptorhynchus mangnifera* of Fabricius. It is a small dark rusty-grey insect about a quarter of an inch long, and, though it and its ravages have long been known, little or nothing has up to the present time been discovered of its habits. It is believed that it lays its eggs in the flower or very young fruit, for in the ripe fruit there is no external mark to show where it gained an entrance, and it is not until the perfect insect eats its way out of the mango that it is possible to tell whether any particular fruit is sound or diseased. Some varieties of the mango enjoy complete immunity from the attacks of this insect, and it has been noticed that even particular trees of varieties which are not so favoûred always escape. This fact seems to hold out the hope that, by careful selection, good varieties of the fruit could be raised which would not be subject to the attacks of this destructive pest. The character which renders the fruit unsuitable as food for the weevil is, and probably always will remain, unknown, as our senses may not be keen enough to detect the particular taste or smell which prevents the female from laying her eggs in the fruit of the naturally protected trees.

Dr. Henry C. McCook is about to issue an elaborate work on "American Spiders and their Spinning-work." It embraces studies extended over more than fifteen years, and will be printed in three volumes. Volumes I. and II. will contain the author's personal observations, studies, and illustrations of the habits and industry of spiders. The studies are particularly directed to the spinning habits of the great group of spiders known as orb-weavers; but these are expressed in their relations to all the other tribes in both hemispheres. Volume III. will contain the systematic part of the work, and embrace descriptions of the orb-weavers of the United States, illustrated by a number of lithographic plates, painted by hand in the colours of Nature. The volumes will be illustrated, wholly from Nature, the number of engravings in the first volume alone exceeding two hundred.

Messrs. J. and A. Churchill hope to publish in September a work on "Fuel and its Applications," by Mr. E. J. Mills, F.R.S., and Mr. F. J. Rowan. It will be the first volume of a large work on chemical technology, of which Mr. C. E. Groves, F.R.S., will be the general editor, and which will be founded on one written by Richardson and Ronalds, familiarly known as "Knapp's Technology." Messrs. Mills and Rowan's work on fuel is in reality a new work, dealing with the applications of fuel to arts and manufactures as introduced by the most modern discoveries. The volume is profusely illustrated.

Messrs. George Philip and Son have published a new edition of Mr. T. Rhodes's useful "Steamship Guide and Holidays Afloat." The work has been thoroughly revised, and much new information is embodied in the present edition.

A work on "The Microscope in the Brewery and Malt-house," by C. G. Matthews and F. C. Lott, will be published early next month by Messrs. Bemrose and Sons.

A Calcutta firm has published a book entitled "The Game, Shore, and Water Birds of India," by Colonel A. Le Messurier, which is an attempt to describe the miscellaneous water-fowl of India. The author treats of the birds under three heads—namely, "Scratchers," "Waders," and "Swimmers,"—and, besides classifying them under these heads, he gives the native names of the birds in the various languages. There are in all 121 illustrations. The book might well be enlarged, particularly by the addition of a list of places where the various species may be found.

The additions to the Zoological Society's Gardens during the past week include a Great-billed Touracou (*Corythaix macrorhyncha*) from West Africa, presented by Lady Charlotte Blandford Griffith; a Water Chevrotain (*Hyomoschus aquaticus*) from West Africa, a Blue and Yellow Macaw (*Ara ararauna*) from Brazil, deposited.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *AUGUST* 25–31.

(For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 25

Sun rises, 5h. 4m.; souths, 12h. 1m. 50·6s.; daily decrease of southing, 16·4s.; sets, 19h. 0m.: right asc. on meridian, 10h. 17·6m.; decl. 10° 37′ N. Sidereal Time at Sunset, 17h. 17m.

Moon (New on August 26, 14h.) rises, 3h. 21m.; souths, 11h. 16m.; sets, 18h. 59m.: right asc. on meridian, 9h. 32·0m.; decl. 18° 0′ N.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	6 33	13 3	19 33	11 18·5	5 16 N.
Venus ...	1 20	9 17	17 14	7 32·4	20 35 N.
Mars ...	3 1	10 43	18 25	8 58·2	18 21 N.
Jupiter ...	15 43	19 36	23 29	17 53·2	23 25 S.
Saturn ...	4 16	11 35	18 54	9 50·6	14 19 N.
Uranus ...	9 28	14 56	20 24	13 12·6	7 4 S.
Neptune..	22 7*	5 57	13 47	4 11·5	19 26 N.

* Indicates that the rising is that of the preceding evening.

Aug.	h.	
25	5	Jupiter stationary.
25	20	Saturn in conjunction with and 2° 28′ south of the Moon.
27	22	Mercury in conjunction with and 4° 42′ south of the Moon.

Variable Stars.

Star.	R.A.	Decl.			
	h. m.	° ′			h. m.
Algol	3 1·0	40 32 N.	Aug.	27,	21 10 *m*
δ Libræ	14 55·1	8 5 S.	,,	29,	0 48 *m*
R Scorpii	16 11·0	22 40 S.	,,	29,	*M*
S Scorpii	16 11·1	22 37 S.	,,	31,	*M*
U Ophiuchi	17 10·9	1 20 N.	,,	28,	3 57 *m*
			,,	29,	0 5 *m*
X Sagittarii	17 40·6	27 47 S.	,,	26,	1 0 *M*
Y Sagittarii	18 14·9	18 55 S.	,,	28,	2 0 *M*
R Scuti	18 41·6	5 50 S.	,,	29,	*m*
U Aquilæ	19 23·4	7 16 S.	,,	29,	1 0 *m*
T Vulpeculæ	20 46·8	27 50 N.	,,	30,	22 0 *m*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
	°	°	
From Pisces	6	11 N.	Swift.
Near β Trianguli	30	36 N.	
,, α Camelopardalis	70	65 N.	Swift; streaks.
,, δ Cephei	336	57 N.	Swift.

GEOLOGY IN RUSSIA.[1]

The Geological Committee of St. Petersburg has made an important contribution to Russian geology by bringing out a new sheet of the Geological Map of Russia, covering the Southern Urals.[2] A volume of explanatory text accompanies the map. It appears from the recent explorations of the members of the Committee that, contrary to the current opinion as to the Southern Urals consisting of a number of chains radiating from Mount Yurma, the great chain consists in its southern parts of a number of chains parallel to one another, and all running from the south-west to the north-east. The main water-parting is built up of granites, syenites, and gneisses, considerably worn down by denuding forces; it has a steep slope towards the east, where its base disappears beneath the Tertiary deposits, while towards the west it is over-

[1] *Memoirs* (vols. ii. and iii.) and *Izvestia* (vols. iv. and v.) of the Russian Geological Committee.

[2] "Carte géologique générale de la Russie," Feuille 139; "Description orographique," by A. Karpinsky and Th. Tchernysheff; "Hauteurs absolues de l'Oural méridional," by A. Tillo; and "Explication de la Carte," by A. Karpinsky and Th. Tchernysheff, in *Memoirs*, vol iii. No. 2. (In Russian, with summaries in French.)

lain by thick beds of Devonian, Permian, and Carboniferous deposits, and these strata are so folded as to make several parallel chains rising more than 3300 feet above the sea, and containing the highest summits of the region. Further west the country assumes the character of a plateau which is built up of nearly horizontal strata of the formation—so characteristic of the Urals—which has a fauna intermediate between the Permian and Carboniferous of Western Europe. Above this there are Triassic deposits.

Several other contributions will be devoted to the same region. One, already published, contains a most elaborate work "On the Lower Devonian Fauna of the Western Slopes of the Urals," by Th. Tchernysheff. Until 1880, the bituminous, gray, and dolomitic limestones of the Urals—very poor in fossils as a rule—were thought to be Silurian, but M. Tchernysheff describes 107 species recently found in these limestones, and shows that their fauna is of Lower Devonian age. This conclusion is of great importance, as it throws light on the age of the very same series of limestones, quartzites, and slates in Siberia and Turkestan (also arrayed in ridges running south-west to north-east).

Another sheet of the geological map covers the most interesting region on the right bank of the Lower Volga.[1] Upper Carboniferous strata appear in that region in the deeper ravines only; the Cretaceous formation is represented by beds belonging to the *étage Aptien* and Neocomian groups of the Lower Cretaceous, as also by the Cenomanian, Turonian, and Senonian groups of the Upper Cretaceous. Nearly the whole of the region is covered, however, by Eocene clays and sands; boulders, partly of local origin, and partly carried from North-Western Russia, are strewn over the surface, and the manner of their distribution is such as to exclude the possibility of transport by floating ice. Prof. Sintsoff concludes, therefore, that the ice-sheet of Russia extended as far south-east as the Volga under the 50th degree of latitude.

Finally, an important contribution to the palæontology of Russia—"The Ammonites of the *Aspidoceras acanthicum* Beds of East Russia"—is published in the same *Memoirs* (ii., 3) by Prof. Pavlow. These beds, which are met with in Simbirsk and the Southern Urals, have a mixed fauna, the characters of which may be best explained by the statement that during the Jurassic period Central Asia was under the sea, and that this basin was in connection with the Jurassic basins of both Tibet and Central Europe.

Besides the above larger works, the Geological Committee has brought out two volumes of *Izvestia* (*Bulletins*), which contain a mass of valuable information. Prof. Mushketoff's notes upon the Kalmuck Steppes are, as usual, rich in most suggestive remarks about the activity of wind and water in the desert. He shows also that during the Quaternary period the Caspian Sea did not extend further west than the Ergheni Hills, communicating with the Black Sea through the Manytch Valley only. In a paper on the limits of glaciation in Central Russia and the Urals (vol. iv.), M. Nikitin shows that the ice-sheet extended in Russia as far south as 48° 30′ N. latitude on the Dnieper, and 50° on the Volga.[2] In a subsequent paper (vol. v.), devoted to the post-glacial deposits of Germany, the same author distinguishes two different kinds of loess, one of which may be due to the agency of wind. Many papers are devoted to the Urals—their crystalline rocks, the traces of glaciation (M. Krotoff, in vol. iv. fasc. 9), and the intermediate Permian-Carboniferous beds, the fauna of which, according to Prof. Stuckenberg, contains forty-one Carboniferous species, thirty-four Permian, seven species belonging to both, and twenty-three characteristic of the Permian-Carboniferous groups. Four papers are devoted by M. Mikhalsky to Poland, and it appears that the beds of Poland, which were formerly thought to be Jurassic, must be regarded as Neocomian—that is, Cretaceous. M. Lagusen describes a new sub-genus, *Lycophoria*, of the *Strophomenidæ* family; Prof. Schmidt deals with the glacial and post-glacial deposits of the Baltic provinces; M. Pavlow describes the *Exogira virgula* beds, as also some Cretaceous and Tertiary deposits of South-East Russia; and M. Nikitin gives a sketch of the Carboniferous deposits and the loess of Samara.

Another work, issued by the Russian Geological Survey, deserves especial mention on account of its general interest and value. This is the annual bibliography of works on geology, mineralogy, palæontology, &c., published in Russia, or works published elsewhere which refer to Russia ("Bibliothèque géologique de la Russie"). Brief abstracts, in Russian with a French translation, are given of the more important papers. The titles are given in the original language; if the original is Russian, then a French version is given; if the original is not Russian, a translation into this language is added.

The publications for the year 1885 number 256; for 1886, 356; for 1887, 405; and for 1888, 390. But the later series include omissions in earlier numbers. The editor of this useful annual is M. S. Nikitin; his chief assistant in the work is Mdlle. Marie Tzwetaev.

[1] "Carte géologique générale de la Russie," Feuille 93; "Kamyschin," by I. Sintsoff, in *Mémoires du Comité Géologique*, vol. ii. No. 2.

[2] An abridged translation of this paper has been published in *Petermann's Mitteilungen*.

SCIENTIFIC SERIALS.

American Journal of Science, August.—On the observation of sudden phenomena, by S. P. Langley. The paper deals with the apparently inherent defects of human observation, especially in recording unexpected natural phenomena, its object being to reduce this personal error to a minimum. The author believes that a means may be found by which any person, skilled or ignorant, may make not only meridian observations, but an observation of any sudden visible event, of whatsoever nature, so accurately that no correction need be applied. An instrument constructed for the purpose, and here illustrated, has been tried by various observers in various ways, the probable error for any single observation being rather less than one-twentieth of a second.—A spectro-photometric comparison of sources of artificial illumination, by Edward L. Nichols and William S. Franklin. These experiments, made in Cornell University during the summer of 1888, consist in the spectro-photometric comparison of various artificial sources of light and of daylight with that emitted by a sixteen candle-power incandescent lamp. The sources of light subjected to measurement were a standard candle, various petroleum and illuminating gas flames, a lime-light, two electric arc lights, clear daylight, an incandescent lamp of high resistance at various temperatures, and an incandescent lamp of low resistance at normal candle power. The general result is that candle-power as determined by means of the Bunsen photometer affords no correct measure either of light-giving energy or of the luminosity of the source of light, the direction of the error always being such as to favour sources of a low degree of incandescence when compared with those of higher temperature.—On the possibility of hemihedrism in the monoclinic crystal system, with especial reference to the hemihedrism of pyroxene, by George H. Williams. A fresh study of the remarkable crystals of pyroxene from Orange County, New York, recently described by the author as hemimorphic, seems to show that they should rather be regarded as hemihedral, and that they are by no means an isolated instance of this peculiar development in pyroxene.—On the earlier Cretaceous rocks of the north-western portion of the Dominion of Canada, by George M. Dawson. The purpose of this paper is to call attention to certain facts recently brought to light respecting the equivalency of the Queen Charlotte Islands and Kootanie formations, and to the importance of the earlier Cretaceous rocks, of which they are representatives, over great areas of the western and extreme north-western portion of the continent. These facts are just now specially interesting from their analogy to those lately developed by Mr. R. T. Hill respecting a similar earlier Cretaceous formation in the south-western region of the United States.—A new occurrence of gyrolite, by F. W. Clarke. This specimen, from the New Almaden quicksilver mine, California, is shown on analysis, and by comparison with How's figures for a Nova Scotia gyrolite, to be a somewhat impure gyrolite associated with apophyllite, and agreeing approximately with the formula $Ca_2Si_3O_8 . 3H_2O$—On action of light on allotropic silver, by M. Carey Lea. The author's further studies of this subject show that light can convert yellow or red-yellow allotropic silver to white, and cause the blue-green modification to pass to the gold-yellow.—Papers were contributed by J. F. Kemp, on certain porphyrite bosses in North-Western New Jersey; by W. B. Dwight, on recent explorations in the Wappinger Valley limestones and other formations of Dutchess County, New York; by George F. Becker, on silicic acids; and by O. C. Marsh, on gigantic horned Dinosauria from the Cretaceous. Mr. Marsh also continues his memoir on the discovery of Cretaceous Mammalia, illustrating the subject with two plates of the teeth of American Cretaceous mammals.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 2.—"On the Spectrum, Visible and Photographic, of the Great Nebula in Orion." By William Huggins, D.C.L., LL.D., F.R.S., and Mrs. Huggins.

I have added the name of Mrs. Huggins to the title of the paper, because she has not only assisted generally in the work, but has repeated independently the delicate observations made by eye.

In the year 1882 I had the honour to lay before the Royal Society a note on the photographic spectrum of this nebula, in which I described a new bright line in the ultra-violet, to which I gave a wave-length of about 3730. In addition to this new line, the lines of hydrogen, $H\beta$ and $H\gamma$, which I had discovered by eye in my early observations on the visible spectrum, were to be seen upon the plate.

On account of the faintness of the object the slit had been placed rather wide, and for this reason the character of the line and its position, as I stated in the paper, could not be ascertained with the accuracy which I desired.

On February 5, 1888, a photograph of the spectrum of this nebula was obtained with a narrow slit; the same apparatus, so far as the essential parts, which were described in my paper, on the "Photographic Spectra of the Stars" (Phil. Trans., 1880, p. 672) being employed.

In this photograph, in addition to the strong line about λ 3730, a pair of less conspicuous lines is seen on the less refrangible side of the strong line.

The continuous spectra due to the two of the four bright stars of the Trapezium which fell upon the slit are present.

Across these continuous spectra at least four groups of bright lines can be seen, of which the greater number can be traced into the nebula for some little distance from the stellar spectra.

It is scarcely necessary to state the importance of this observation as showing that these stars of the Trapezium are not merely optically connected with the nebula, but are physically bound up with it, and are very probably condensed out of the gaseous matter of the nebula. This observation would seem also to show that the nebula, as a whole, may not be at a distance from us greater than that which we should attribute to such stars, if they occurred alone in the heavens.

The first group, of six lines, occurs between λ 4116 and 4167. The lines of this group do not extend far from the continuous star spectra, with the exception of two lines. These can be seen faintly in another photograph taken in 1889. Beyond there is a fainter group, probably of four lines a little beyond *h*. I am pretty sure that these lines extend into the nebula. The third group from λ 3896 to 3825, of which I have endeavoured to measure ten lines, is faint, but here there is no doubt that the same lines are present in the adjoining nebular matter. There are two lines a little more refrangible than the strong line seen in 1882, at about λ 3709 and λ 3699. I have a suspicion of a faint group about this place, and also of another group on the less refrangible side of G.

I shall discuss further on, the probable chemical significance of these lines.

During the time that Orion was favourably situated for observation in the season of 1888 and in that of the present year, the unusual continuance of bad weather made it impossible for me to give so complete an account of the spectrum of the nebula in the photographic region as a few really fine nights would have enabled me to do. However, on February 28 of the present year I obtained another photograph, the slit being very narrow, which gives some more new information of the nature of its spectrum. I was astonished on looking at the photograph not to see the strong line about λ 3730, which was by far the most conspicuous feature of the photograph taken in 1888. The pair of lines near it on the less refrangible side, which I found for the first time in 1888, are present; and on a further scrutiny of the plate I discovered two other pairs of lines, most probably rhythmically connected with them, in the still more refrangible region, the last pair, accompanied by a third line, being near the ultra-violet limit of ex-terrestrial light.

I was also able to see faintly two of the bright lines which I have described as present across the continuous spectra of the brighter stars of the Trapezium in my photograph of 1888. It is not quite certain whether these very faint and short lines are really due to the matter of the nebula proper, or have come upon the plate in consequence of the stars of the Trapezium having fallen accidentally upon the slit for a time too short to impress the continuous part of their spectra. No trace of a continuous spectrum can be seen upon the plate, but these lines in the plate of 1888 do extend beyond the continuous spectra of the stars of the Trapezium.

I regret extremely that bad weather has made it impossible for me to work out the circumstances on which depended the disappearance of the strong line about λ 3730. Both the photographs which show this line include two stars of the Trapezium, and it may possibly be that this strong line is associated with the groups near it in the spectra of the stars, and may therefore come out in those parts of the nebula only which are more condensed. A few photographs with the slit differently placed upon the nebula would doubtless have thrown light upon this point. The suggestion presents itself strongly that the mottled and broken-up character of the nebular matter, shown in Lord Rosse's drawing from eye observations, and much more strikingly brought out in the recent photographs of Mr. Common and Mr. Roberts, may be connected with differences of spectrum in the photographic region, though in the visible region there is no known alteration of the spectrum of the four bright lines, except, it may be, some small differences of relative brilliancy of the lines.

Until next winter we cannot go beyond the new information which these photographs give to us. On the plate of the photograph of 1889 two pairs of spectra for comparison were taken: two spectra, one above and one below the nebular spectrum, of burning magnesium; and two spectra, similarly placed, of the light of the sky.

From the photographs of 1888 taken with a narrow slit, the position which I gave in 1882 to this line is shown to be, as I expected from the wide slit then used, approximate only. I find from the later photograph that the wide slit had caused the strong line to unite with a line near it, and that in 1882 I measured the middle of the broad band produced by the union of the wide images of two lines. Its position is about six tenth-metres more refrangible. It does not therefore agree, as I then suggested, with the hydrogen line ζ in my spectra of white stars. A statement of the position of this line relatively to the magnesium-flame triplet will be given further on, when I come to discuss the comparison of this spectrum with that of the nebula.

The position of the pair of lines a little less refrangible than this strong line, seen with it in the photograph of 1888, and present without the strong line in the photograph of 1889; and the positions of the two other more refrangible pairs, presumably connected with the first pair, are given in the following table:—

1st pair about	λ 3752·0 3741·0
2nd pair about	3285·0 3275·0
Line at about	3060·0
3rd pair about	3053·0 3047·0

In both photographs I suspect the indications of other lines, which are too faint to permit any certain conclusion to be formed about them, whether they are true lines, or imperfections only of the film.

[The continuous spectra of the stars of the Trapezium can be seen on the plate from about F to about λ 3570, but they are very faint beyond λ 3660.—*May* 18.]

The Visible Spectrum.

a. Brightest line.—In 1872 ("On the Spectrum of the Great Nebula in Orion, &c.," Roy. Soc. Proc., vol. xx. (1872) p. 383), I stated, as the result of numerous direct comparisons of this line with the brightest line in the spectrum of nitrogen, that the nebular line was "sensibly coincident with the middle of the less refrangible line of the double line of nitrogen." To avoid repetition I will call this line N_1. Except where it is otherwise stated, I use this line of nitrogen simply as a fiducial point in the spectrum, without any reference to its chemical significance.

In a still more critical examination of the position of the nebular line for the purpose of determining whether there was any indication of relative motions of the gaseous nebulæ in the line of sight, I found some experimental difficulty from the circumstance that the nebular line is narrow and defined, while N_1 is nebulous. I was fortunate to find a more suitable fiducial line of comparison in a narrow line of lead, which falls almost upon the middle of N_1 ("On the Motions of some of the Nebulæ towards or from the Earth," Roy. Soc. Proc., vol. xxii. (1874) p. 252). In December 1872, I compared this line directly with N_1, and found it sufficiently near in position to serve as a fiducial line of comparison.

Six other gaseous nebulæ were also examined, each on several nights, with the result that "in no instance was any change of relative position of the nebular line and the lead line detected" (*ibid.*, p. 253).

In the simultaneous observation of the nebular line and the lead line, it was found if the lead line was made rather less bright than the line of the nebula, the small excess of apparent breadth of this latter line appeared to overlap the lead line to a very small amount on its less refrangible side, so that the more refrangible sides of the two lines appeared to be in a straight line across the spectrum. The clearness of position of the two lines was shown by the observation that when the line of the nebula passed across the field of the spectroscope, and the lead line was thrown in, the lead line was not seen, but only an increase in brightness of the nebular line. By comparing the end of the nebular line near the Trapezium where it is refined to a point, I estimated that the difference of position of the middle of the lead line and that of the nebular line might be possibly from λ 0000·2 to λ 0000·3 (*ibid.*, p. 252). Some recent measures of the position of the lead line with the middle of N_1 show that the lead line is about λ 0000·12 more refrangible.

These direct comparisons of the nebular line with the lead line confirmed, therefore, my former conclusion, that the brightest line in the gaseous nebulæ is very near N_1, when seen under a dispersion equal to nearly eight prisms of 60, namely 36° 25′ from A to H.

This result is based on direct comparisons, on twenty-four different nights, with N_1 or with the line of lead.

The wave-length of N_1 has been determined by Kirchhoff, Thalén, and by myself. Watts's reduction of my measure to wave-lengths is clearly not accordant with my measures of air lines immediately preceding and following this line. I have therefore reduced my original measure to wave-lengths, and find for N_1 the value λ 5004·5.

Kirchhoff	5004·6
Thalén...	5005·1

Thalén's value is clearly too high, as Thalén gives for the lead line, coincident nearly with N_1, λ 5004·6, and N_1 is seen on the more refrangible side of the solar iron line given by Ångström as λ 5004·9. In Ångström's map N_1 is laid down on the more refrangible side of the iron line 5004·9, at about 5004·5. The same position is given to N_1 in Kirchhoff's map.

I have made a new determination of the position of N_1, using the second spectrum of a grating 17,300 to the inch, relatively to the solar iron line at 5004·9 according to Ångström.

The value came out λ 5004·6, which agrees with Kirchhoff's value, and with Thalén's measure of the lead line which falls upon it, and also with the maps of Ångström and of Kirchhoff.

The wave-length of the brightest nebular line may therefore be taken at from

λ 5004·6 to λ 5004·8 . . . . (1)

The micrometric measures of this line, given by D'Arrest, Vogel, and Copeland, agree closely with this value.

D'Arrest's[1] mean value	5004
Vogel's ,, ...	5004
Copeland's[2] ,, ...	5004

b. Second line.—In 1872 (Roy. Soc. Proc., vol. xx., 1872, p. 385), I stated that I had found this line, by comparison with a line of barium, and subsequently with an iron line, to have

A wave-length of	λ 4957·0 . . (2)
D'Arrest's mean value from micrometric measures	λ 4956·6
Copeland's mean value from micrometric measures	4958·0

c. Third line.—In my original paper (Phil. Trans., 1864, p. 437), "On the Spectra of some of the Nebulæ," in 1864, I showed, by direct comparison with hydrogen, that this line is undoubtedly the line of that gas at F of the solar spectrum. This observation was afterwards repeated (Phil. Trans., 1868, p. 545), and has been confirmed by the photographs of 1882 and 1888.

[1] "Undersögelser over de nebulose Stjerner" (Copenhagen, 1872, p. 23).
[2] *Monthly Notices R.A.S.*, vol. xlviii. p. 361.

The wave-length of this line is therefore	λ 4860·7 . . (3)
D'Arrest's value from measures	4860·6
Copeland's ,, ,, ...	4861·0

d. Fourth line.—In 1872 (Roy. Soc. Proc., vol. xx., 1872, p. 385) I stated that I had satisfied myself of the coincidence of this line with Hγ, but, on account of its faintness, it is very satisfactory to find this observation of coincidence confirmed by the photographs taken in 1888 and 1889. There can be no doubt that this is a line of hydrogen, and that

The wave-length therefore is	4340·1 . . (4)
Copeland's mean value	4342·0

Dr. Copeland gives the measures of two still fainter lines which he has seen in this nebula—namely, one at λ 5874, possibly coincident with D_3, and a line at λ 4476 (see also Mr. Taylor, *Monthly Notices R.A.S.*, vol. xlix. p. 125). I defer the consideration of these and other faint lines which I have often suspected in the faint continuous spectrum of the nebula, as in consequence of the great strain upon the eyes from my recent direct comparison of the spectrum of the nebula with the spectrum of burning magnesium, I was not able, during the very few fine nights when Orion was favourably situated, to undertake an examination for these very faint lines.

Comparisons with the Magnesium-flame Spectrum.

In 1882, Dr. Copeland, in his paper on Schmidt's Nova Cygni (*Copernicus*, vol. i. p. 109), remarked in a foot-note, "that it is worthy of note that this line (λ 5006·5 of burning magnesium) almost absolutely coincides with the brightest line in the planetary nebulæ."

This line—namely, the bright edge of the first band in the magnesium-flame spectrum—is very near in position to the brightest nebular line. We have seen that the wave-length of this line in the nebulæ (1) is 5004·6 to 5004·8; now the wave-length of the end of the magnesium-flame band is 5006·5, consequently it does not coincide with the nebular line, but falls on the less refrangible side at a distance of λ 0002 nearly from that line.

The wave-length of the termination of the magnesium-flame band is, as determined by—

Lecoq de Boisbaudran	5006·0
Watts	5006·5
Liveing and Dewar[1]	5006·4

I have recently determined the position of the end of the band, by direct comparison with the solar iron line given by Ångström at λ 5006·58.

My result places the magnesium-flame band line at λ 5006·5 . . . . (5)

In a paper read before the Royal Society in 1887,[2] Mr. Lockyer says:—"Only seven lines in all have been recorded up to the present in the spectra of nebulæ, three of which coincide with lines in the spectrum of hydrogen, and three correspond to lines in magnesium. The magnesium lines represented are the ultra-violet low temperature line at 373, the line at 470, and the remnant of the magnesium fluting at 500. the brightest part of the spectrum at the temperature of the bunsen burner." At p. 137 (*loc. cit.*) Mr. Lockyer says:—"In the nebulæ we deal chiefly with lines seen in the spectrum of magnesium at the lowest temperature."

In a later paper in 1888 ("Suggestions on the Classification of the various Species of Heavenly Bodies," Roy. Soc. Proc., vol. xliv. p. 21) Mr. Lockyer states:—"In a paper communicated to the Royal Society on November 15, 1887, I showed that the nebulæ are composed of sparse meteorites, the collisions of which bring about a rise of temperature sufficient to render luminous one of their chief constituents—magnesium. This conclusion was arrived at from the facts that the chief nebular lines are coincident in position with the fluting and lines visible in the bunsen burner when magnesium is introduced, and that the fluting is far brighter at that temperature than almost any other spectral line or fluting of any element whatever."

Although the number of direct comparisons which I had made of the brightest line in the nebulæ with N_1 and with the lead line, not to speak of the accordant results of the micrometric measures of other observers, left little doubt in my mind that this line could not be coincident with "the remnant of the mag-

[1] Roy. Soc. Proc., vol. xliv., 1888, p. 245.
[2] "Researches on the Spectra of Meteorites: a Report to the Solar Physics Committee." Communicated to the Royal Society at the request of the Committee. Roy. Soc. Proc., vol. xliii. p. 118.

nesium fluting at 500," really at 5006·5, yet I thought it desirable to undertake the laborious task of comparing, with the necessary care and precautions, the nebular line directly, in the spectroscope attached to the telescope, with the spectrum of burning magnesium.

Arrangements were made by which the light from burning magnesium was thrown into the telescope from the side and then reflected down, under conditions similar with the light from the nebula, upon the slit of the spectroscope. By this arrangement any flexure in the tube connecting the spectroscope with the telescope would affect both spectra alike. The coincidence in position of the spectrum from burning magnesium with that of a heavenly body to which the telescope was so directed that its light fell upon the slit of the spectroscope, was tested with great care on several occasions by comparing the three bright lines of magnesium with the corresponding lines, b_1, b_2, b_4, in the spectrum of the moon. Indeed, to prevent any possible error in the observation of apparent want of coincidence of the nebular line, if the light from the burning magnesium should by an accident so come upon the slit as to bring its spectrum in a very minute degree on the less refrangible side of its true position relatively to the nebular line to be observed with it, the arrangement was purposely made that the lines of magnesium were seen to fall upon the corresponding dark lines at *b* in the moon, a very little on the more refrangible side of the middle of those lines. This state of things would diminish a little the interval which should be seen between the nebular line and the edge of the magnesium-flame band, and so make the determination more difficult; but if under such circumstances the nebular line was seen on the more refrangible side of that of magnesium, the observation would be much more trustworthy, for in the case of coincidence with magnesium the line would have appeared towards the opposite and less refrangible side of the magnesium line, broadening the magnesium line on this side. I considered that the comparison could be made most satisfactorily by the complete superposition of the two spectra, that from burning magnesium being gradually reduced in brightness by the interposition of coloured glass screens, until the ground of the spectrum between the successive bright lines of the band of the magnesium-flame spectrum was sufficiently subdued to allow of the nebular line being seen upon it.

Under these circumstances, if the nebular line had the position which my direct comparisons and the micrometric observations of other observers assign to it, it would be seen as a bright line at a very small interval within the line ending the band, and to the observer the band would appear to commence with a double line.

This direct comparison was first successfully made on March 6, 1889. The observations were made with the 15″ refractor belonging to the Royal Society. The spectroscope used has two compound Grubb prisms, each with 5 square inches of base, and giving nearly twice the dispersion of a single prism of 60°, namely, 9° 20′ from A to H; and collimator and telescope of 1·25-inch aperture. An eye-piece magnifying eighteen times was employed. The nebular line was brought upon the cross-wires, and when carefully focussed and clearly seen, the light from burning magnesium was thrown in. This observation is one of great difficulty, especially as the interval to be observed had been purposely reduced by causing the magnesium to fall, for the sake of the greater trustworthiness of the observations, on the more refrangible side of its true position. Although I consider the results to be satisfactory, I prefer to say that I, and Mrs. Huggins independently, believed fully at the time that we saw the appearance which all former observations of this line led me to expect—namely, the nebular line to fall within the termination of the magnesium band, and to form with the band-boundary a double line. The relative positions of the two spectra are represented in diagram across the page. The line at the end of the magnesium band was then brought upon the cross-wires, without any attention being given to the nebular line; when the burning magnesium went out, the nebular line was seen to be at a measurable distance to the left of the intersection of the wires—namely, on the more refrangible side.

When the object glass of the telescope was covered, the magnesium band presented its usual appearance—namely, terminating in a single line. These comparisons were repeated and confirmed generally on March 9, March 11, and March 16. On March 9 a single successful comparison was made with a more powerful spectroscope, giving a dispersion equal to nearly eight prisms of 60°. [Comparisons have been made since with the planetary nebula in Hydra. The short line of the nebula was found to fall within the termination of the magnesium band at about the small distance which corresponds to the known position of the two lines.—*April* 26.] On all these nights the comparisons were repeated independently and fully confirmed by Mrs. Huggins.

These comparisons can be successfully imitated in the laboratory by directing a spectroscope of sufficient power to the line of lead which the nebular line is sufficiently near, the slit being narrow, and the electrodes of lead near each other; and then causing, with the necessary precautions, the light of burning magnesium to fall also upon the slit. The lead line will be seen to fall within the end of the band, and to form with it a double line.

It may be mentioned in this place that this line of lead, and the iron line at 4957 at the position of the second nebular line, can be conveniently used in the laboratory in any chemical research on the nature of the nebulæ. No terrestrial line which does not fall almost exactly at these positions in the spectrum can have any claim to further consideration.

(*To be continued.*)

PARIS.

Academy of Sciences, August 12.—M. Des Cloizeaux, President, in the chair.—Remarks in connection with the "Introduction à l'étude des Races humains," Part II., presented to the Academy by M. A. de Quatrefages. In this second part the author passes from the general questions touching the evolution of man to those touching the evolution of the human races, of which he reckons at least one hundred and seventy-two, exclusive of minor varieties, all however reducible to the three fundamental black, yellow, and white stems. Adhering to the natural method of classification, as understood by Jussieu and Cuvier, he divides these stems into *branches* corresponding to primary and secondary divisions, under which come the *families* and *groups*. Much stress is laid on the early migrations of man, resulting in crossings of all sorts, and the general displacement of pure by half-caste races. The position of fossil man in the general scheme of classification is also studied, the five or six known varieties discovered in Europe being divided into two distinct branches allied to the white stock. Two distinct Quaternary types are also recognized in America, that of the Pampas affiliated to the Siberian, and that of the Lagoa Santa to the Eskimo branch of the yellow stock. Some bold speculations are indulged in regarding the primæval homes of the three fundamental groups and their subsequent dispersion from common centres over the face of the globe. In this scheme the north of Asia is considered the cradle of mankind, whose three primary divisions grouped themselves round the great central tableland, whence they gradually spread over the continents during Tertiary and Quaternary times. In the Oceanic world the Eastern Polynesians are affiliated to the white, the Melanesians (Papuans) to the black, and the Malays to the yellow stock, each division migrating from the mainland in the order already indicated by Prof. Keane ("Indo-Chinese and Inter-Oceanic Races and Languages"). The work is illustrated with 441 figures inserted in the text, four plates, and seven maps.—On a general law of induction in circuits devoid of resistance, by M. G. Lippmann. In this study the author proceeds exactly as in rational mechanics, where the fundamental laws are established, apart from the disturbing element of friction, which is afterwards considered as a particular force. He seeks the most general law of induction by assuming resistance to be null, and justifies this procedure *a posteriori* by the simplicity of the results, by their easy application and agreement with recent experiments.—On the vascular apparatus in animals and plants, studied comparatively by the surgical and thermochemical methods, by M. Sappey. In previous communications the author showed that in the vertebrates the thermochemical method is not only useful but preferable to the older process for the study of certain organs, especially the harder parts. In the present paper he directs attention to the structure of the vascular apparatus in plants and animals studied both by the surgical and thermochemical methods. The latter process is shown to yield as complete, accurate, and satisfactory results as could be desired; it is unquestionably superior to the former in the analysis of the veins and arteries of animals, and of the woody and other vessels of plants.—The virus of diphtheria, by M. C. H. H. Spronck. The author communicates the results of the researches on human diphtheria made by him, jointly with MM. Wingtens, Van den Brink, and Van Herwerden, in Utrecht. The disorder is studied chiefly in connection with its action on the region of the kidneys.

These researches seem to leave no doubt that the bacillus of Klebs is the real active principle in diphtheria.—On the rotatory polarization of quartz, by M. H. Le Chatelier. Having already shown (*Comptes rendus*, May 20, 1889) that towards 570° C. the dimensions of quartz undergo a rapid increase, if not an absolutely sudden change such as that noticed in dimorphic transformations, the author here endeavours to place beyond doubt this sudden change by resuming the study of the rotatory polarization of quartz already begun by M. Joubert. From his investigations it seems evident that at the specified temperature this body really undergoes a sudden allotropic transformation while retaining under both states its rotatory power as well as its crystalline symmetry.—On the production of crystallized cobaltous and ferrous hydrates, by M. A. de Schulten. The author has obtained these hydrates in the crystallized state by using the same method that has enabled him to prepare artificial brucite and pyrochroite, as explained in the *Comptes rendus*, ci. p. 72, and cv. p. 1265.—Papers were contributed by M. C. Patein, on a source of error in the search for, and quantitative analysis of, albuminoid substances in the animal organism; by M. Maupas, on the agamous multiplication of some rotifers and other lower Infusoria; and by M. Th. Moureaux, on the cause of certain disturbances in the curves of the magnetographs.

Berlin.

Physiological Society, July 26.—Prof. Munk, President, in the chair.—Prof. Zuntz spoke on heat-regulation in man, basing his remarks on experiments made by Dr. Loewy. The store of heat in the human body at any one time is very large, equal in fact to nearly all the heat produced by the body during twenty hours, hence the heat given off to a calorimeter during a given period cannot be taken as a measure of the heat-production; this determination must be based rather upon the amount of oxygen consumed, and of carbonic acid gas given off. The purpose of the experiments was to ascertain what alteration the gaseous interchange of the body undergoes by the application of cold, inasmuch as existing data on this point are largely contradictory. The observations were made on a number of men whose respiratory gases were compared, during complete rest, when they were at one time clothed, at another time naked, at temperatures from 12° to 15° C., and in warm and cold baths. Each experiment lasted from half an hour to an hour, during which period the gases were repeatedly analyzed. As the result of fifty-five experiments, twenty showed no alteration of oxygen consumption as the result of cooling, nine gave a lessened consumption, while the remaining twenty-six showed an increased using up of oxygen. This diversity of result is explicable on the basis of observations made by Prof. Zuntz, who was himself experimented upon, as to his subjective heat-sensations during the experiments. He found that after the first impression due to the application of cold is overcome, it was quite easy to maintain himself in a perfectly passive condition; subsequently it required a distinct effort of the will to refrain from shivering and throwing the muscles into activity, and finally even this became no longer possible, and involuntary shivering and muscular contraction supervened, as soon as the body-temperature (*in ano*) had fallen $\frac{1}{2}$° to 1° C. During the first stage of cooling, Zuntz's oxygen consumption showed a uniform diminution; during the period also in which shivering was repressed by an effort of the will, cooling led to no increased consumption of oxygen, but as soon as shivering became involuntary there was at once an increased using up of oxygen and excretion of carbonic acid. This explains the differences in the results of Dr. Loewy's experiments, and may be taken to show that in man, and presumably in all *large* animals, heat-regulation as directly dependent upon alteration (fall) in temperature of the surrounding medium does not exist; the increased heat-production is rather the outcome of the movements resulting from the application of cold to the body. In *small* animals, on the other hand, there undoubtedly exists a heat-regulation dependent upon an increased activity of chemical changes in the tissues set up by the application of cold to the surface of the body, and in this case the thermotaxic centres in the brain most probably play some part.—Dr. Herter gave an account of experiments made by Dr. Popoff on the artificial digestion of various and variously cooked meats. Lean beef and the flesh of eels and flounders were digested in artificial gastric juice; the amount of raw flesh thus peptonized was in all cases greater than that of cooked meat similarly treated. The flesh was shredded and heated by steam to 100° C. The result was the same for beef as for fish. When compared with each other, beef was on the whole the most digestible, but the amount of fish-flesh which was peptonized was sufficiently great to do away with the evil repute which fish still has in Germany as a proteid food. Smoked meat differed in no essential extent from raw meat as regards its digestibility.—Dr. Cowl described his experiments on the mechanical latent period of a muscle. The muscle was hung up by one end, and its movements were recorded by a lever passing through the middle of the muscle, and writing on a spring-myograph. When both electrodes (using a "breaking" induction shock) were applied to the half of the muscle above the lever, the curve obtained showed a short latent period, after which it rose above the base-line. When the electrodes were applied below the lever, the same latent period was observed, after which the curve first fell slightly below, and then rose above the base-line. When one electrode was applied above and the other below the lever, then the elongation of the muscle was now present, now absent; in the latter case the length of the latent period was equal to the latency plus the duration of the visible elongation. From this it follows that the elongation of the muscle accounts for part of the latent period.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Iron and Steel Manufacture: A. H. Hiorns (Macmillan).—Magnetism and Electricity: A. W. Poyser (Longmans).—Carta Topografica della Liguria (Philip).—Traité Encyclopédique de Photographie, tome premier, Matériel Photographique: C. Fabre (Paris, Gauthier-Villars).—Trinidad, Annual Report of the Royal Botanic Gardens and their Work for 1888: J. H. Hart (Port of Spain).—La France Préhistorique: E. Cartailhac (Paris, Alcan).—The Republic of Uruguay; General Description and Statistical Data, 1888-89 (Liverpool, Rockliff).—Report of the Fourth Indian National Congress, held at Allahabad in 1888 (London).—Smithsonian Annual Report for the Year ending June 30, 1886, Part 1 (Washington).—Schriften der Physikalisch-ökonomischen Gesellschaft zu Konigsberg in Pr., 1888 (Konigsberg).—Journal of the Bombay Natural History Society, vol. iv. No. 1, (Bombay).—Proceedings of the Royal Society of Victoria, vol. i., new series (Williams and Norgate).—Journal of the Royal Agricultural and Commercial Society of British Guiana, June 1889 (Stanford).—Quarterly Journal of the Geological Society, vol. xlv. Part 3, No. 179 (Longmans).—Studies from the Morphological Laboratory in the University of Cambridge, vol. iv. Part 3 (Clay).

CONTENTS.

THURSDAY, AUGUST 29, 1889.

THE SCIENTIFIC WORKS OF SIR WILLIAM SIEMENS.

The Scientific Works of Sir William Siemens, LL.D., D.C.L., F.R.S. 3 Vols. (London: John Murray, 1889.)

THE "Life of Sir William Siemens," which was noticed in the pages of NATURE some months ago, has been followed by three most interesting volumes containing a reprint of his scientific papers. The task of editing the collection was committed by the executors to Mr. E. F. Bamber, for many years private secretary to Sir William Siemens, and it has been admirably discharged. The labour has been no light one; for the volumes contain, besides the greater and more highly finished contributions to the learned Societies, a very large number of extracts from the published proceedings of the various Societies and from the scientific journals—reports of the speeches delivered by Sir William Siemens during the discussions at scientific meetings.

Many of these papers are of high scientific importance, particularly to various classes of engineers, electricians, and chemists; and the whole collection forms a monument of unusual interest, exhibiting the many-sided nature of Siemens' labours and inventions. Both the papers and the unwritten speeches are very remarkable for clearness of thought and of style. Siemens was pre-eminently a man who made up his mind with complete decision, after careful thought, on whatever came before him. This decisiveness gave him the power of taking hold of a matter by the right end in the exposition of it: and the consequence is a clearness of thought and of diction which are alike unusual and satisfactory. The reader seldom requires, even in the case of descriptions of complicated apparatus, to reperuse a sentence; nor is it ever difficult to follow the reasoning on which an opinion is based.

Of the three volumes before us, the first contains the contributions of Siemens to the subjects of heat and metallurgy. The second is mainly taken up with electricity and miscellaneous subjects; while the many lectures and addresses, which from time to time he was called upon to deliver, are collected in the third volume.

It is impossible, in a brief article like the present, to review in detail these substantial volumes, or offer any lengthened criticism of their contents. We must content ourselves with such brief notice of them as will indicate to our readers some of the chief features in the life-work of this remarkable man.

In the second volume, under the heading "Miscellaneous Subjects," will be found two papers of no great length, but of special interest. These papers contain an account of Siemens' improved water-meter. Of what vast importance this invention proved to the inventor is probably not generally known. To use a common expression in the widest sense, "it made his fortune." It was his first thoroughly successful invention; and it gave to the young engineer the pecuniary assistance (greatly needed at the time) which enabled him to push forward into higher and yet higher regions of invention and success.

The meter was invented in 1850–51, and patented in 1852. It satisfied the tests of a committee of inquiry of the Manchester Corporation Waterworks; and very soon a large number of the meters were at work, and were giving complete satisfaction. The general principle is that of using "various arrangements of screws or helices, which are caused to revolve by the passage of water or other fluid through them, and of fixed guides and channels in connection with such screws or helices to regulate and direct the current of the fluid, together with various contrivances for registering the number of revolutions of the screws." For the larger meters a many-bladed screw is used, the blades and guides being properly shaped that the blades may "partake fully of the onward motion of the water without sensibly impeding or agitating the same." For the smaller meters a kind of Barker's mill is used, with conditions as to the inlet and outlet arranged to fulfi the object in view.

"From a practical point of view," says Mr. Pole, in his "Life of Siemens," "the Siemens water-meter has been one of the most useful and valuable machines ever brought into hydraulic engineering. . . . . Down to the end of 1885 nearly 130,000 meters had been sold by Messrs. Guest and Chrimes (the first makers) alone, and in many cases it has been established as the standard apparatus for the sale of water." The two papers contained in the present volume were contributed in 1854 and 1856 to the Institution of Mechanical Engineers, and they contain a full discussion of the conditions necessary to be fulfilled by a water-meter, and descriptions, with illustrative drawings, of the inventions in this direction of the author.

In the first volume are contained the papers of Siemens on heat and metallurgy. These are well known to all workers in these departments of science and industry, and a brief notice must suffice here, in spite of their vast intrinsic importance. Very early in his life we find Siemens devoting his attention to the "regenerative principle" in heat. The words "regenerator" and "regenerative" are most unfortunate—utterly misleading to those who attempt to imagine the nature of the "principle" from the name by which it is called. The names, however, were not due to Siemens, but to Dr. Stirling, inventor of the hot-air engine; and it is worthy of being mentioned here that Siemens objected to the name, and wrote to Mr. Manby, a friend of Dr. Stirling, that "perceiving him (Stirling) to repudiate the name of 'respirator,' I really think he would confer a benefit on posterity if he would give his child a proper name, that of 'regenerator' being certainly incorrect, and likely to produce misconception."

The name "respirator" readily suggests the nature of the principle here spoken of. The metallic plate of a respirator, used by delicate people to protect the lungs or throat, takes up the heat of the outgoing breath and parts with it again to the air which is inspired; and this is precisely the principle of the heat-saving arrangements with which the name of Siemens is so closely connected. It may be, however, that a better name than either of these could easily be found.

In this first volume of the papers we find the titles of many communications describing arrangements for heat-saving and for obtaining increased temperatures by causing what would otherwise be waste heat to warm the air or gaseous fuel used in the process of combustion. Thus we have a "regenerative condenser for high-pressure and low-pressure steam-engines"; a "regenerative steam-engine"; the regenerative furnace applied to glass houses and to various metallurgical processes—to the manufacture of steel, the puddling of iron, &c.

Towards the close of his life, Siemens took up warmly the question of abatement of smoke in large towns, and economy in domestic heating and lighting. Accordingly we find interesting and important papers on the use of coal-gas as a fuel, and on gas supply both for heating and illuminating purposes. These papers contain a description of a regenerative domestic fire and a regenerative gas-lamp. It is very surprising that the views of Siemens on these important subjects have been so little appreciated by the gas companies on the one hand, and by the general public on the other. The smoke nuisance becomes year by year more and more terrible in our large towns; while the gas companies are undoubtedly neglecting to take advantage of sources of enormously increased profits to themselves.

Space fails us to enter into any detailed account of the important papers on metallurgy contained in the second part of the volume just now before us. In these are elaborated the descriptions of his improvements in iron processes. The two main features of the inventions are, first, the production of "mild steel," as it is called, of a quality surpassing that obtained by older processes; and, second, the production of first-class steel by the "direct process"—that is, directly from the ore instead of from the pig-iron of the blast-furnace, or from puddled iron. It is probable that even now, when there are over a million tons of steel being produced annually in Great Britain alone by the processes of Siemens, we are far from seeing in full the results of these improvements. It must be remarked, however, with regard to the direct process that the very existence of the enormous establishment of blast-furnaces in this and other countries constitutes a formidable adversary to its introduction.

The volume containing the papers of Siemens on electrical subjects is naturally divided into two parts: one containing papers on cable-laying, &c., and the other on the production of electricity by the dynamo-electric machine, and its application when so produced. The life of Siemens was intimately associated with the electrical developments which have made the last forty years startling in the rapidity of growth and improvement. By the electric telegraph, the commercial and social relations not only of individuals, but of the nations, have been revolutionized; while with regard to the dynamo-electric machine, much as its invention has accomplished, there can be no doubt but that its past and present are but infinitesimal compared with its future importance. The papers of Siemens must always have exceptional interest in connection with the early history of these two industries.

We cannot do more here than mention a few of them. First we have three papers largely taken up with land-line telegraphs, and giving an account of the progress which Dr. Werner Siemens was making in Germany, both in the construction of telegraph lines and in the improvement of telegraph instruments. Next we meet with a paper describing a machine for covering telegraph wires with india-rubber. Then we have contributions to the tests of deep-sea cables; and again, a paper on the outer covering of deep-sea cables. A most interesting paper gives an account of the steamship *Faraday* and her appliances for cable-laying. The *Faraday* was built with the object of laying the Direct United States cable, and was fitted with every appliance which the experience of former great submarine cables had suggested as important. A number of minor papers give descriptions of accessory instruments and appliances connected with the work of laying down deep-sea cables. Thus we have a deep-sea thermometer, the bathometer, &c., described in short interesting memoirs.

The papers connected with the production of electricity by the dynamo-electric machine, and of the uses of the great currents so produced, deal with a department of science and industry in which Sir William Siemens and his brothers were pioneers. The Siemens family, and the manufacturing firms of Siemens in this country and in Germany, designed and produced machines which undoubtedly were the best of those early days, and which served Siemens in setting on foot the first electric railways, the first electric furnaces, and first and only experiments on horticulture by electric light.

Only a few lines remain to us in which to refer to the third of these volumes. A man of Siemens's power and standing, and one who was able to speak with authority on so many subjects of high scientific and commercial interest, was naturally called on to give many more or less popular expositions of these subjects. Many lectures and addresses were therefore obtained on various occasions from this gifted and public-spirited man. These are collected in the third volume of the papers. Here we find addresses on deep-sea telegraphs, testing electric cables; on fuel, a popular lecture to the working classes under the auspices of the British Association at Bradford; on air-engines and steam-engines, in which the regenerative principle is explained; on utilization of heat, a lecture under the Glasgow Science Lectures Association; on waste, delivered to the Coventry Science Classes; several addresses and speeches on subjects connected with the production and uses of steel. We have also addresses which he delivered as President of various learned Societies—as President of the Mechanical Section of the British Association; two addresses to the Society of Telegraph Engineers, two to the Iron and Steel Institute, his address as President of the British Association in 1882, and many other minor addresses and speeches.

Among other subjects on which Siemens had thought deeply, is the highly important one of technical education, which is exercising the minds of so many at the present time. He had more than common opportunities for forming a correct judgment on the requirements of those who are to advance the various arts and industries of the world; and his knowledge of Germany and England, and of German workmen and English workmen in very varied departments, gave him special title to speak with authority on this subject. The consequence is that in many of his shorter addresses and speeches very valuable remarks and criticisms are to be found on this question so vital to our national prosperity.

In taking leave of these important volumes, we cannot but feel that scant justice has been done to them in this brief article. It is only a very small proportion of the subjects on which Siemens thought and wrote to which we have been able even to allude. Very many subjects occupied his active mind, and it is most remarkable how thoroughly and completely each one of them was worked out and brought down to a definite conclusion. Much he attempted; and pre-eminently he acted on the principle that "whatever is worth doing is worth doing well."

THE ADVANCEMENT OF MEDICINE.

Reports from the Laboratory of the Royal College of Physicians, Edinburgh. Edited by J. Batty Tuke, M.D., and G. Sims Woodhead, M.D. Vol. I. (Edinburgh and London: Young J. Pentland, 1889.)

IT is a healthy and most welcome sign of the increased interest taken in pathological research that, at the conclusion of what is but the first year of its existence, the laboratory instituted by the Royal College of Physicians of Edinburgh has been able to issue a volume of Reports of such importance as the one lying before us. When, further, it is noted that this is, if we mistake not, the first volume of its kind published in the United Kingdom—the first collection of papers emanating from a single laboratory, and treating of pathology alone—then the energy that is being displayed north of the Tweed in the advancement of medicine by research should gain the cordial appreciation it well deserves.

Willing as our own Royal Colleges of Medicine have of late shown themselves to encourage investigation, they have, from a variety of causes, been unable to bring forward their schemes to a practical issue with the rapidity and thoroughness displayed by their Edinburgh *confrère*, and although the idea of instituting a research laboratory has for long engaged the attention of the authorities in Lincoln's Inn Fields, we are still very far from seeing that laboratory in complete working order.

It must be admitted that, to devise the details of a new departure such as this is far from being an easy task. Many and opposing interests have to be taken into account, and, as may be gathered from Dr. Sims Woodhead's introductory article, at Edinburgh, despite the ardour of Dr. Batty Tuke and his Committee, nearly two years elapsed before plans could be developed to the stage at which they were at the same time feasible and acceptable to the College of Physicians. But, this stage once passed, no time was lost. A commodious house was taken and adapted to the required purposes, a scientific superintendent appointed in the person of Dr. Woodhead, and in the course of a very few weeks the laboratory was ready.

The regulations laid down by the College are conceived upon a broad and generous basis. The laboratory is open without fee to Fellows and Members of the College, and, with the sanction of the Committee and Curator (Dr. Batty Tuke), to any Licentiate, and "to any medical man or investigator who shall obtain the sanction of the Council of the College, as well as of the Curator and Committee, to use the laboratory for the purposes of scientific research." The scientific superintendent, while himself undertaking the prosecution of original research, shall be prepared to assist, if required so to do, in the work of the investigators, and it would appear that leave having once been given to work in the laboratory, little or no restriction is placed upon the investigators with regard to the nature of their work beyond the broad control exercised by the superintendent. All these points are worthy of attention at the present time when a similar institution is in the process of development in London. This volume, coupled with the fact that during the first year two-and-twenty investigators in one or other department of medicine have made use of the laboratory, yields full evidence of the success of the scheme.

We note with some curiosity what is apparently an effort to reconcile opposing views as to the functions of the new laboratory, in the regulation requiring the superintendent to furnish the Fellows of the College "with reports. . . upon the histology of morbid specimens and of the chemical and microscopic characters of urines." Certainly, by undertaking work of this kind the laboratory becomes of very definite service to the Fellows, and could our English Colleges, for example, see their way to the institution of departments to which members might send any morbid material as to whose nature they desired advice, they would, by adding largely to the possibilities of a correct diagnosis, confer no little benefit upon the public, apart from the benefit they would bestow upon their members. It is, however, questionable whether this form of work falls within the province of medical corporations; it is still more questionable whether such work can wisely be required of one whose time and energies, as director of a research laboratory, are liable to be wholly utilized in a very different direction.

Coming now to the consideration of the papers which form the volume before us, we may say that they well exemplify the tendencies and traditions of the Edinburgh medical school. Bacteriology is represented by the details of an investigation into the air of coal-mines; by Dr. Woodhead's very able "Notes upon the Use of Mercuric Salts in Solution as Antiseptic Lotions"; by the report of an inquiry undertaken in Japan as to the causation of cholera, the work of Dr. N. Macleod and Mr. W. J. Miller (tending to confirm Koch's views); and also by the condensed report of Dr. Woodhead's lectures before the Grocers' Company upon tabes mesenterica and pulmonary tuberculosis. This last, and Dr. Bruce's article upon a case of absence of the corpus callosum in the human brain, are both of very general scientific interest, and represent the accurate and thoughtful work done at Edinburgh in the domain of pathological histology; while the large proportion of four papers out of the eleven of which the volume is composed, reflects the prominent position long held by Edinburgh in the department of gynæcology.

With scarce an exception, the reports bear upon practical matters, and have more than an academic value. But at the same time they exhibit the one especial weakness of the school. Pathology, embracing as it does the whole of medicine save the treatment of disease, is capable of being advanced by two equally valuable methods, the synthetic and the analytic, as they may be termed: on the one hand by studying the part played by individual factors in producing diseased conditions, and, on the other, by determination of those factors through examination of diseased organs; that is to say, by the methods of experimental pathology and pathological anatomy respectively. The first of these is almost unrepresented in the volume, save by the record of work done away from Edinburgh. We venture to express a hope that, the laboratory offering as it does every facility, this neglect of constructive pathology is apparent and not real, and that it is due not to the absence of experimental inquiry, but to the fact that investigations along these lines have not become completed in the course of a short twelve months.

The facts and suggestions contained in the article upon tuberculosis, by Dr. Woodhead, above referred to, are deserving of a far wider circulation throughout the country than is rendered possible by the conditions under which they now appear. On the Continent, and, especially at this moment, in France, the infectiousness of tuberculosis, and the appalling extent of its distribution, is at length exciting that serious and general attention which precedes active measures. No disease contributes so largely to the lists of mortality. As Dr. Woodhead points out, the maximum affection by mesenteric tubercle—by tuberculosis of the lymphatic glands of the intestines—is attained between the ages of one and five years, and a large mass of evidence would seem certainly to indicate that the cause is to be sought for in the milk derived from tubercular cows.

"Many Commissions on the subject have sat, and have delivered themselves of what must, to all who know anything about the matter, seem most sound judgments, but nothing is done. Where is our inspection of milk—not a mere chemical analysis—but a thorough chemical and biological examination? Where are our clauses for the compulsory notification of disease, either in the farm or the farm-house? Where are our regulations for the examination at regular intervals, and by competent veterinary authorities, of the cattle from which the milk is derived? . . . We must strike at the root of the whole matter as regards the connection between bovine and human tuberculosis. We then not only remove one set of centres of infection, but in so doing we, in turn, diminish the number of human centres from which the disease may spread."

Finally, a word is deserving to be said concerning the appearance of the volume. No expense has been spared in making the reports worthy of their origin. The type is large and clear, the individual contributions are well and profusely illustrated; the appearance of the volume, as a whole, is excellently calculated to make critics fulfil the motto of the College displayed ingenuously upon the back—"*Non sinit esse feros.*" J. G. A.

TREATISE ON HYDRODYNAMICS.

Treatise on Hydrodynamics. Vol. II. By A. B. Basset, M.A. (London: George Bell and Sons, 1888.)

THIS second volume of Mr. Basset's "Treatise on Hydrodynamics," the publication of which followed at no long interval that of his first volume, is in all respects a fitting complement to that work, and fulfils the expectations of value and completeness aroused by its appearance.

The prevailing impression on studying this volume and contrasting it with the first is, that many more avenues for research and discovery lie open in the subjects here treated, than can possibly be found in the more fully explored parts of hydrodynamics that constitute the subject-matter of the first volume.

This impression is borne out by the fact that many results here collected together are the results of recent years, placed in this volume in a more accessible form than when engulfed in the original papers. When we find that this book enters fully into such diverse branches of the subject as vortex motion, tides, and viscous fluids —not that these exhaust its contents—we can realize the width and variety of reading necessary to make the matter of the book as valuable and accurate as it unquestionably is, and also the probability that the author must expect to see these chapters rendered incomplete by the advance of knowledge in these directions.

The chapters on vortex motion owe their results and form largely to the writings of Prof. J. J. Thomson; in the discussion of the stability of the vortex it seems impossible to evade long and arduous algebraical processes, even though the kinematical surface condition used may be of the simplest. The author himself has given in addition an investigation of the fluted vibrations of a circular vortex ring, making use of toroidal functions, and obtaining the same equation for the periods as in the case of similar vibrations of a columnar vortex.

We have read with considerable interest a method given in the first chapter on vortex motion, in which the principle of inversion is applied for the first time to a hydrodynamical problem. It is true that its success is restricted to cases of motion in two dimensions; but a new field might be opened up if, by use of co-ordinates in an inverse system, the ordinary equations of motion would admit of yielding at once two solutions to each problem, in a way similar to the electrical method of inversion. Apparently, the co-ordinates cannot so be changed, nor is any simplification obtainable in the case of viscous fluids, where certain product terms are always disregarded.

Another most interesting chapter is that on the motion of a liquid ellipsoid under its own attraction; here the various shapes possible to rotating fluid are passed in review, and, placed as they are in order, beginning with the familiar instance of Maclaurin's spheroid, the necessary criteria that separate one possible surface from another are easily distinguished.

The question of the stability of some of these shapes is considered, and reference made to the papers of Poincaré in the *Acta Mathematica*, though certain *ex cathedrâ* statements in Thomson and Tait's "Natural Philosophy" have to go unexplained.

To enter on the discussion of waves and tides seems, by contrast with vortices, to begin a fresh subject, so totally distinct are the equations and methods; yet these two chapters are not the least valuable in the book. The chapter on waves contains all the known solutions of waves in canals or on the sea, and also includes Sir G. Stokes' masterly investigation of the form of the wave-front in the deep sea. In the chapter on tides, after a brief account of the equilibrium theory, Prof. Darwin's version of Laplace's dynamical solution is laid under contribution.

The last four chapters of the book are devoted to viscous fluids, and include, besides the theorems usually given, the oscillatory motion of a sphere and cylinder, published first by Stokes in 1850, and also a solution, due to the author, of the motion of a sphere under any forces. In this latter, certain integrals suggested by the theory of conduction of heat are used to obtain the equation of motion of the sphere, the solution of which can be obtained by approximation.

Certain miscellaneous theorems find a place in the last chapter, including an article on the effects of viscosity on a vortex sheet, which plainly has an important bearing on the practical determination of the stability of such a sheet.

The very full array of references to original papers adds considerably to the usefulness of this work, which is in all respects one of the most valuable on mathematical subjects that has appeared for some time. The results are accurate, the discussion of each branch is thorough and complete, and the analytical methods are powerful and in touch with the most recent developments.

THE LAND OF MANFRED.

The Land of Manfred, Prince of Tarentum, and King of Sicily: Rambles in Remote Parts of Southern Italy, with Special Reference to their Historical Associations. By Janet Ross. Illustrated by Carlo Orsi. (London: John Murray, 1889.)

THAT part of Italy lying to the south-east, forming the "heel," was once a land full of stirring events, but it has long lapsed into a state of semi-oblivion; to tell of its past glories and its present prospects is the object of this charming little volume by Mrs. Ross.

Italy seems possessed of powers of rejuvenescence, and the time appears approaching for the revival of some of the past glories of this "Land of Manfred." The traveller from Naples can now journey by rail from Naples to Taranto and Brindisi, and thence by the East Coast line north to Bari and Manfredonia; but, to get some idea of the beauty of this fair portion of Italy, one must leave the iron road and wander over flowery meads, climb up the gently sloping hills crowned with many an ancient castle and overlooking the grey olive gardens and out to the blue encircling sea; then in some measure can the land's loveliness be comprehended. This district of Apulia is not only out of the range of the ordinary tourist, but is even to this moment so little known to the inhabitants of Northern Italy that it is regarded by them as not safe to travel in; the newly-made lines of railway, the building of a great harbour for the Italian fleet at Taranto, will no doubt speedily dissipate such notions. These pages of Mrs. Ross's will undoubtedly tempt many of her compatriots to visit this fair unknown land, to its and the travellers' benefit; and they will also show that the perils of Apulia consist solely in bad inns —a peril getting less and less each season.

Many of the towns along the coast were visited by Mrs. Ross, and the leading events connected with their history are very graphically described; such as Manfredonia, Trani, Barletta, Bari, Brindisi, Otranto, and Taranto. Of the more remarkable inland places visited may be mentioned Castel del Monte, Foggia, Lucera, and Benevento.

As the chief events associated with each city or town are recorded, it is difficult to make a selection. At Bari the immense fortress-like priory attracted deserved attention; the crypt is described as formed of pillars, apparently innumerable, with their capitals richly carved in every conceivable design. Under the silver altar were the bones of St. Nicholas. The Cathedral of St. Sabinus was even more ancient than the Priory of St. Nicholas, its crypt being said to have existed in 733.

To tell of all the churches and cathedrals mentioned, and castles and fortresses described, would be but to reprint the volume, so we must content ourselves with transcribing the charming description given of Sir James Lacaita's residence at Leucaspide. The *loggia*, or arcade, running all along the south-west front of Leucaspide, overhangs a garden full of orange trees, wallflowers, stocks, Parma violets, carnations, and roses; beyond, an expanse of brilliant green corn grown under the colossal olive trees, said to be 2000 years old; then a belt of cultivated land, across which now and then the white smoke of a rushing train reminds us that we really are in the nineteenth century; and last a long line of dark pines, which fringe the Gulf of Taranto. On the opposite side of the Bay rise the Basilicata Mountains, tipped with snow, and further to the left, dimly perceptible on a clear day, are the wild and rugged hills of Calabria. The whole country is redolent of rosemary, and in the Gravina or deep ravine of Leucaspide, the myrtle, white and pink gum-cistus, the lentick and wild pears, were in a blaze of bloom. Troops of small black sheep, with eyes like topazes, graze upon thyme and other fragrant herbs among the rocks, while their shepherd dressed in a waistcoat and trousers of goat-skin, all made in one, leans against a tree or a wall, and plays wild and melancholy music on a little pipe made out of a cane.

The clever sketches by Carlo Orsi assist in illustrating a country about which Mrs. Ross tells us much, but about which it seems evident there is much more to be told, and about which we may hope to have from the same pen some still further details.

OUR BOOK SHELF.

The Zoology of the Afghan Delimitation Commission. (Trans. Linn. Soc., Zoology, Vol. V., Part III.) By J. E. T. Aitchison, M.D., C.I.E., F.R.S., &c.

ALTHOUGH this is very far from being a complete account of the fauna of North-Western Afghanistan, there is good reason to congratulate the author on his success in collecting a fairly representative series of the animals inhabiting the frontiers between Afghan and Russian territory. As Dr. Aitchison explains, his special calling is that of a botanist, and he undertook the office of collecting the fauna under considerable difficulties. The specimens obtained, representing 16 mammals, 123 birds, 35 reptiles, 2 batrachians, 7 fishes, about 100 insects, and a few *Arachnida*, *Myriopoda*, and *Crustacea*, were determined, and the new forms described, by the officers of the British

Museum, notes on distribution, &c., being added by Dr. Aitchison.

The publication by the Linnean Society of the whole series of descriptions in one fasciculus is a manifest advantage. If it has no other effect, it may perhaps convert from error some of those who, like the contributor of the part "Aves" to the last four numbers of the *Zoological Record*, still retain the mistaken idea that the Afghan fauna belongs to the Oriental or Indian region Not only does the prevalence of genera like *Arvicola*, *Ellobius*, *Cricetus*, and *Alactaga*, among mammals; *Pica*, *Accentor*, and *Phasianus*, amongst birds; *Teratoscincus*, *Phrynocephalus*, *Scapteira*, *Taphrometopon*, and *Vipera*, amongst reptiles; and *Schizothorax*, amongst fishes, show plainly the Palæarctic character of the fauna, but there is a remarkable absence of Indian types, with the exception of wide-ranging forms like the tiger, which is found here and there in suitable localities throughout Central Asia, from the Caucasus to the banks of the Amoor (and which, as its absence from Ceylon shows, is doubtless a comparatively recent immigrant into the Indian peninsula). A few species, like the wild ass and *Ovis cycloceros*, extend into the extreme north-west of India, but cannot possibly be said to form a part of the typical Indian fauna. Even amongst non-migratory birds, only two or three kinds, like *Pratincola caprata* and *Lanius vittatus*, are characteristic Indian species, and the forms named have a considerable range beyond the limits of the Oriental region.

It is interesting to find that some of the naturalists who have described the *Invertebrata* notice affinities between the forms collected and those inhabiting the Mediterranean basin. The *Vertebrata*, on the other hand, are characteristically Central Asiatic, as is shown by the genera already noticed.

The illustrations are excellent, and the representation by figures of all species of insects and *Arachnida* described as new is much to be commended. W. T. B.

A Text-book of Paper-making. By C. F. Cross and E. J. Bevan. (London: E. and F. Spon, 1889.)

An increase in the number of technical schools and institutes will no doubt call for a number of trustworthy text-books on various chemico-mechanical industries, arranged not only for the student proper but for the manufacturer as well; indeed, it is perhaps the latter who needs and can use a good text-book to greatest advantage.

It would be well for us if we had other text-books as commendable in their particular connection, and as clear, concise, and thorough, as this on paper-making chemistry, for that is what it amounts to.

The authors state in their preface their belief in the importance of a scientific training for paper-makers. This of course would apply to many trades besides paper-making with equal force. As the earlier and most important operations in paper-making are of a purely chemical nature, or at any rate more chemical than mechanical, the authors have very rightly treated this portion more fully than the mechanical operations proper, which would involve descriptions of complex machines and details not exactly fitted for a text-book of an instructive nature as this.

The introductory note and chapter i. treat of the chemical properties and composition of cellulose and its varieties as far as is known at present. It is a somewhat concentrated chapter on the natural history of this class of substance, and to appreciate it fully the reader should already have a fair acquaintance with the more common chemical processes and elementary principles. It is a useful and valuable chapter, and nobody is better able to discuss it than the authors. The same applies to chapter v., in which processes for isolating cellulose from plant substances are considered.

The chapter on the special treatment of fibres is a very exhaustive one. The remainder of the book—with the exception of short sections on "chemical analysis" for paper-makers, and "paper-testing," and the "Willesden paper"—is taken up with the more mechanical part of paper-making. They are very fully illustrated with large diagrams.

Many besides paper-makers will find interesting matter and much information in this book. W. R. H.

Boilers: their Construction and Strength. By Thomas W. Traill, F.E.R.N., M.Inst.C.E., Engineer-Surveyor-in-chief to the Board of Trade. (London: Charles Griffin and Co., 1888.)

As a hand-book of rules, formulæ, tables, &c., relative to material, scantlings, and pressures for boilers, this volume will prove most useful. The name of the author is a sufficient guarantee for its accuracy. It will save engineers, inspectors, and draughtsmen a vast amount of calculation, and the fact that the information is calculated from formulæ embodying the Board of Trade practice will add greatly to the confidence of those using it in any particular design. The tables contain over 60,000 results, and include in their scope most of the information required in any ordinary case. Engineer inspectors will also find valuable information pertaining to the qualities of iron and steel generally in use, and many good hints as to what ought to be allowed or prohibited in the ordinary working of the material. Among the many duties of the Board of Trade inspectors is that of determining a safe working steam-pressure for old boilers. In the tables relating to this subject thin plate scantlings are given. The decision as to a suitable pressure must, of course, to a large extent depend on the actual condition of the old boilers under inspection, whether the plates are corroded or pitted, and on the condition of the stays and rivet heads. One hears an occasional "growl" about the severity of the Board of Trade inspection, but there is no branch of engineering more carefully and conscientially done than that under Mr. Traill's control, and the present volume should be of great service to his inspectors. The work is the result of much thought and labour, and the author deserves the cordial thanks of all who have to design and superintend the construction of boilers. N. J. L.

Lord Howe Island: its Zoology, Geology, and Physical Characters. Printed by order of the Trustees of the Australian Museum, Sydney. (Sydney: Charles Potter, 1889.)

In 1887, by the order of the trustees of the Australian Museum, Sydney, a collecting party was despatched from Sydney to Lord Howe Island. Most of the results of the expedition are described in the present volume. An excellent epitome of the general zoology of the island, by Mr. R. Etheridge, Jun., is first given. Then come detailed descriptions of the specimens obtained by the members of the party. Mr. A. J. North deals with oology, Mr. J. Douglas Ogilby with reptiles and fishes, Mr. A. Sidney Cliff with insects, Mr. R. Etheridge, Jun., with geology and physical structure, and Mr. T. W. Edgeworth David with rock specimens. The memoir also includes descriptions of various collections made in Lord Howe Island, by Mr. Alexander Morton, in 1882; of collections, chiefly entomological, made by Mr. George Masters, in 1869; and of some gatherings made by Mr. E. H. Saunders after the return of the Museum party. The contributors to the volume have evidently striven to write accurately, concisely, and clearly, and everyone who may have occasion to consult their work will admit that it is well done. The various papers are carefully illustrated. We may note that the descriptive account of the Mollusca is not yet ready, but that the plates are here issued in advance.

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.*]

Sunset Glows at Honolulu.

THERE has just been at Honolulu a reappearance of the phenomenon of sunset glows like those so familiar in 1883–84. It was first noticed after sundown of July 13. It seemed somewhat brighter on the 14th and 15th. After this it declined in intensity, but could be distinguished until the 20th.

A space of 15° radius around the sun was occupied by a whitish glow like that in "Bishop's ring." The outer coloured ring seemed to be entirely wanting.

We have no cable, and no foreign mail has arrived since the 6th. By a mail due to-morrow, we hope to hear of a probable cause to which this remarkable appearance may be due.

I note the following differences between these sunset glows and those of 1883–84. These are very much less bright than those; possibly equal to what those became after one year's continuance. Perhaps the most notable difference is the appearance of a tertiary glow after the primary and secondary. This consisted of a delicate rosy flush occupying a large tract of sky above the western horizon, from the altitude of 10° to that of 45°, and about 60° horizontally. This shaded off into purple at the edges against our clear blue Hawaiian sky. I think this the most exquisite and lovely tint I have ever seen in the sky, comparable only to that of some perfect jewel.

The larger stars were visible at the time of this tertiary glow. It continued for only a very few minutes each evening. A faint purple tint extended along the horizon quite to the south. This third glow failed to gather down upon the horizon like those preceding it.

Another marked peculiarity is the much earlier time at which the primary and secondary take place. The primary glow gathers soon after the sun is down, and makes its display while the sky is still bright. So it fails to be very effective as a show, although casting upon the western sky broad streaming radiations of glowing surface.

The secondary glow promptly follows and makes the chief display. It differs from the secondary Krakatão glow in the earlier time when it takes place, being nearly finished before any stars are visible. The Krakatão secondary lingered until after full darkness, settling down into a low blood-red stratum simulating the reflection of a remote conflagration. That peculiar simulation was entirely absent from the late appearances. Both at its close and throughout its course this secondary glow substantially resembles the primary glows as seen in 1884. It especially resembles the latter in presenting a well-defined and serrated upper edge bordered by dark sky. That, however, had small and numerous serrations, apparently due to cumuli upon a very remote horizon. The serrations of this, on the contrary, are large and broad, the interspaces being apparently the inverted shadows of cloud-masses upon a somewhat near horizon.

It seems evident that the reflecting stratum of haze in the late appearances was very low down as compared with the Krakatão haze. Hence the rapid succession of the glows. The reflected rays of the sun, traversing a much smaller extent of the lower atmosphere, show less red, having less of the other colours intercepted. For the same reason, they retain force enough for a third reflection, in which a very pure though faint red appears.

Honolulu, July 25. SERENA E. BISHOP.

Globular Lightning.

THE following account of a display of globular lightning will, I think, be of interest to your readers, as it was well observed by several independent observers, and differs in some respects from those previously recorded. It is greatly to be wished that this phenomenon could have its place assigned to it in electrical theory.

On Monday, the 5th instant, at midday, this district was visited by a violent storm of rain, which lasted half an hour, and was accompanied by thunder and lightning. When the storm had passed over and the sky was getting bright, a rod-like object was seen to descend from the sky. It is described as being of a pale yellow colour, like hot iron, and apparently about 15 inches long by 5 inches across. These dimensions are given by an observer who estimated its distance (about correctly, as it subsequently appeared) at 100 yards, and are not therefore affected by the uncertainty attaching to estimates of the sizes of objects whose distance is quite unknown. This object descended "moderately slowly," "not too fast to be followed by the eye" and quite vertically.

On reaching a point about 40 feet from the ground, and in close proximity with a chimney-stack belonging to a house in Twickenham Park, the object seemed to "flash out horizontally as if it burst," showing an intensely white light in the centre and a rosy red towards the outer parts. At the same instant a violent explosion was heard, and soon afterwards a strong smell was perceived, which is described by the observers as "resembling that of burning sulphur," for which the smell of ozone and nitric oxide might easily be mistaken.

Ordinary lightning is frequently most capricious in its action. In this respect this globular flash was in nowise behind.

I examined the outside of the chimney stack carefully, but no external effect whatever was visible. Inside, however, remarkable effects were produced, and I quote the following:—

"The back rooms consist of (1) basement kitchen; (2) ground floor dining-room; (3) first and second floor bed-rooms, and at the top a half attic. A stack of chimneys runs up the whole, and projects about 6 feet above the roof. There are no chimney-pots. No one was in any of the rooms except the kitchen, in which the servants were, and in which a fire was burning.

"The explosion filled the kitchen with smoke and soot. The dining-room also was filled with smoke and soot, though no fire was burning in it.

"The master of the house was just coming into the dining-room from the conservatory when he heard the detonation and simultaneously saw a bright flash of light. He staggered back a moment, and then ran through the smoke and soot to the hall, and called out to know if anyone was hurt. Finding all safe he returned into the dining-room. A Japanese umbrella set open as an ornament in the empty grate, but not fixed in any way, was undisturbed, though the hub of it was hot to the touch. Piles of soot spread out in a semicircle to the centres of the side walls of the room, and an arm-chair, which had been standing close to the fire-place, was 6 feet from its previous position, and had evidently been turned round and thrust against the wall. In the bed-room, on the first floor, soot was on the floor and in the fire-place. The slab of marble forming the architrave under the mantel-shelf, and extending the whole width of the fire-place, had been thrust out from its setting, and was, with a number of bricks, lying 6 feet away on the floor. The mantel-shelf and pier-glass were undisturbed. In the second-floor bed-room, soot and mortar were in the fire-place and on the floor; one end of the grate was broken and a piece of the detached cast iron (some 3 inches square) was lying against the wall 6 feet to the right. In the attic bed-room, mortar reduced to the condition of fine silver sand was lying in the fire-place and on the floor; the wash-stand, which stood against the fire-place, was pushed some 2 or 3 feet towards the centre of the room, but not overturned; and the carpet was rumpled up. There is in this room a bell on the wall opposite the fire-place, and a helical check-spring passes from this bell to an attachment in the wall. At this point of attachment a piece of plaster of the size of one's hand had been detached from the wall, and was found near the fire-place, 18 feet off at the other end of the room."

At this time, when electrical theory is receiving so much attention, the views of a theorist such as Dr. Lodge would, I think, be of great interest on the subject of these rare discharges. To all appearance a detached portion of something—is it atmospheric, or ethereal?—is carried along bodily through the air, bearing with it a very considerable potential energy, and at the same time radiating light. At an instant determined, perhaps, by its proximity to the chimney-stack, its constraint is suddenly relieved, and a discharge like ordinary lightning seems to occur between it and the earth, *viâ* (as it seems) the heated air of the chimney. Has anyone an explanation for this?

A. T. HARE.

Neston Lodge, East Twickenham, August 24.

On some Effects of Lightning.

I CAN fully corroborate Mr. A. F. Griffith's account of the remarkable way in which two trees in a wood near St. Albans have been broken in two, and rent to splinters, by lightning. The first tree which he mentions, however, suggests very forcibly that the "explosion" must have occurred at the core of the tree, for long wedge-like splinters of the wood have been forced outwards, and are now projecting from the stem. The fact, also, that the whole of the bark was in each case torn off, and projected in every direction round about the trees, can be accounted for only by an impulse proceeding from the middle of the stem southwards. One feature of the case which Mr. Griffith did not mention is the twisting which seems to have occurred with the second tree: the portion which is nearly broken off appeared to have been twisted through about 90°, and the portion of the stem which is left standing is also considerably twisted in the same direction; as to the stem, however, it is difficult to estimate how much of the twisting may be due to the growth of the tree.

That any part of the effects are due to wind, is, I think, quite out of the question. It is indeed a curious sight to see two sound oak-trees, some 6 or 8 feet in circumference at their base, broken off, twisted, and torn to splinters, as if they had been so much matchwood; but one of the most remarkable features of the case appears to me to be, that there are *two* trees which have been treated in almost exactly the same manner. If it were the effect of one shock, that shock must have divided itself into nearly equal portions, and must have struck two trees which are some 30 yards apart, which do not stand in any isolated position, and which are separated from each other by several other trees, all of which remained untouched. On the other hand, it is quite inconceivable that two shocks of such an exceptional character should have occurred within a few yards of the same spot, and should have produced identical effects of such an extraordinary character.

The case is one which certainly deserves investigation.

Harpenden, August 18. SPENCER PICKERING.

Some Lake Ontario Temperatures.

THERE are, among the great lakes of the St. Lawrence, exceptional opportunities for observing the effect of heat and cold upon large bodies of fresh water. The vast area and depth of the lakes, the different latitudes in which they lie, and the extremes of heat and cold of the Canadian seasons, all combine to render observations of interest.

It thus far appears that, in their main expanse, Lake Superior and the Georgian Bay (the eastern basin of Lake Huron) constitute, in midsummer, great bodies of colder water—the former registering at the surface as low as 39½° F. (Hind), and the latter at 10 fathoms indicating 45° F., and, at the bottom, even lower than 39½° F. (Boulton). On the other hand, the lower lakes, including Ontario, are shallower than Superior, lie in warmer latitudes, have some affluent streams from even farther south, and may be said to have perceptible, though light, currents through them. The temperatures of their waters are thus very different from those of Lake Superior and the Georgian Bay. Thus, on May 6 of this year, at 4.15 p.m., Commander Boulton, R.N., found the surface of the water off Griffiths Island, in the Georgian Bay, 35° F., and the bottom, at 60 fathoms, 35½° F.; whilst on May 23, at 11 a.m., near the outlet of Lake Ontario—my first soundings there—I found the air (the day being calm and cloudy) 55° F., the surface-water 52¼° F., and the bottom at 13 fathoms 50¼° F., and this was after a cool and exceptionally windy spring.

Some general results, which seem warranted by very numerous thermometer-readings near Kingston, may be of interest. The north-east end of Lake Ontario here does not usually exceed 20 fathoms in depth, but through it flow into the St. Lawrence all the waters of the great lakes.

Areas of Water of Different Temperatures.—At the surface the water is not uniform in temperature, even at points relatively near each other, and which appear to have the same conditions —the variations being generally from 1° to 3°. At different depths down to the bottom there are equally marked variations. In the tributary streams similar results appear. In a shallow creek fully exposed for an eighth of a mile to the sun's rays, and slowly flowing over a succession of limestone ledges, the mercury, in 1½ inch of water on a warm June afternoon, could be seen rising and falling between 81° and 83° F. Here there were exceptional causes, but in the line of outflow from the lake to the St. Lawrence the fluctuations are to be ascribed rather to the great evaporation at the surface, and the cooler waters beneath ascending to supply the place of the evaporated water. As the evaporation would be irregular, varying with the passing clouds, and the gusts of wind, the ascending currents would also be irregular. These ascending waters would give rise to an inflow at the bottom from the deeper and cooler parts of the lake to take their place, and both these currents would be affected by the general light onward flow of the lake waters towards the entrance of the St. Lawrence.

Gradual Absorption of Heat.—The general rise in the temperature of the Lake Ontario waters as the summer advances is at first slow compared with the general rise in the temperature of the air, but as midsummer is reached, the rise is more rapid both at the surface and at the bottom. A comparison with temperatures from Lake Erie will, eventually, better explain this. The circumstance, however, has its bearing on the well-known modifying effect of great bodies of water on the climate of the immediately surrounding land. In illustration of it, on June 14, at noon, when the air indicated 79¾° F., the surface water in the main channel—2 miles from Kingston—was still as low as 57½° F., or only 5° higher than on May 23. On July 5, the readings in the same place had increased to 69½° F., with the air at 79° F., and on July 10 to 74¾° F., with the air at 92¾° F., the thermometer always being in the sun. The most marked change was between June 25 and July 5, when the advance registered was 9°. The bottom temperatures indicate somewhat similar results. On May 23 at 13 fathoms the deep sea thermometer registered 50¼° F.; on June 14 at 12 fathoms, 52° F.; on July 10 at 17 fathoms, 53° F.; and on July 25 at 12 fathoms, 67° F.

The absorption and retention of the sun's heat is, however, most noticeable in the small streams and quiet pools. There we find well illustrated the general proposition that in high temperatures the surface of comparatively still water, where unaffected by deep under currents, absorbs and retains the heat of the sun to a much greater degree than the immediately overlying air. A marked example of this was observed in the shallow lightly flowing stream already referred to, where on June 14 at 3.15 p.m. the air at 3 feet above the water indicated a slight breeze 73° F., and at the surface 76°, whilst the water at 1½ inch registered 83° F., at 4 inches varied between 79½° and 82½°, and at 7 inches on the bottom fell to 72½° F. The records of other creeks did not indicate such extremes, but showed that each stream in its current, bottom, and surroundings, may have circumstances which vary the temperature. In very shallow, still pools, exposed freely to the sun and breeze, the difference between the air and water surface temperatures is even more marked, the water on sunny afternoons in June and July showing about 11° higher range. In such shallow, still pools, however, the water, though indicating some variation, is tolerably uniform in temperature, even to the bottom.

Effect of Channel Currents.—Near Rockport, among the Thousand Islands, there is a broad and deep channel where the current down the river runs at about 2 miles an hour. Here at 37 fathoms, in different localities, the deep sea thermometer gave the same readings as the surface thermometer, showing that the water was completely churned up.

Another illustration was in the Gananoqui River immediately below the falls. The temperature at the bottom here on June 10 was 62¾° F.; a quarter of a mile down stream at the outlet to the St. Lawrence, it was 61½° F.; in the St. Lawrence, 150 yards off the outlet, 57° F.: and 200 yards further up the St. Lawrence, 54¼° F.; the surface water at each of these points varying only between 62¼° and 63° F. These records show how the deeper and colder waters of the St. Lawrence gradually asserted themselves on coming into contact with the Gananoqui River waters. A. T. DRUMMOND.

The Yahgan.

THE tribe in Tierra del Fuego described by the Rev. C. Aspinall are called the Yahgan (Jahgan being a German form and not the English). The missionaries have translated the Gospels into Yahgan with some interpolations of special English terms. There are two or three other distinct languages for the scanty population. It can be seen that the Yahgan is a language of Old World roots, and words can be recognized that philologists determine to be typical Aryan roots. The variety of languages is a fact noticeable among small exogamous communities, and it is a matter of interest to find such variety at the extremity of the New World. H. C.

Electrolysis of Potassium Iodide.

THE following form of this experiment differs from that producing blue iodide of starch usually given in text books, and as I am not aware of it being known it may be of interest to those engaged in teaching the subject to which it belongs.

Into a U-tube pour a solution of the salt coloured with red (slightly acid) litmus solution, then, on introducing the electrodes (carbon for the anode) and passing a current, the solution in the anode limb is turned brown, due to the solution of I in KI, while at the kathode the liquid turns blue from the liberation of potassium.

This form of the experiment is very pretty, and is suitable for large classes.

For small classes the poles of a battery may be drawn over red litmus paper moistened with KI solution.

It is well to exhibit the action of iodine and potassium (potash) upon separate portions of the red solution before conducting the experiment. E. F. MONDY.

Dacca College, Bengal, July 24.

Spherical Eggs.

WILL you allow me to thank Profs. Greenhill and Liveing for their notes in reply to mine on the question of the packing of spherical eggs. The chief drawback of life in New Zealand is the inaccessibility of works of reference, such as those mentioned by Prof. Greenhill. W. STEADMAN ALDIS.

Auckland, New Zealand, July 11.

ANOTHER PHOTOGRAPHIC SURVEY OF THE HEAVENS.

WE gather from two circulars received from Prof. Pickering that another photographic map of the heavens is to be made, in addition to that arranged for at the Paris Conferences. The first circular runs as follows:—

It is proposed to establish an Astronomical Observatory on one of the mountains of Southern California, under climatic conditions probably superior to those at any similar institution now existing, with possibly one or two exceptions. It is therefore extremely important to increase these natural advantages by a plan of work and form of instrument which shall give results such as cannot be obtained elsewhere. Moreover, in California the interest in astronomy is wide-spread. There are many persons of large means who might be willing to make an important contribution to science if they could be sure that the promised results would be attained. The plan detailed below provides for a telescope with which stars could be studied that would be beyond the reach of any other instrument. The amount of material accumulated would be far greater than that obtained by telescopes of the usual form. A satisfactory test of the work could be made before a large part of the money had been expended. No great delay would probably arise, so that the donor could soon see the results arising from his gift. When money is given to erect a building without sufficiently endowing it, the value of the gift is greatly diminished if the name of the donor is attached to the building. This objection does not hold in the present case, since a large part of the expenditure is for current work. On the other hand, the donor's name would always be honourably associated, not only with the instrument, but with the work done with it. As in the case of the Henry Draper Memorial, it is believed that by such a living reminder a patron of science will be more widely known and appreciated than by a much larger expenditure for a building or fund.

Photography is rapidly changing the older methods of astronomical study. It gives an accurate representation of many objects at the same time; and, since copies may easily be made, it permits the results to be studied at leisure at any place and time. In a recent paper before the National Academy of Sciences, the writer recommended the construction of a large photographic telescope of the form described below. The lens should be like that used by photographers rather than like that of an astronomical telescope, and should consist of two achromatic lenses. Its aperture should be 24 inches, and its focal length 11 feet, thus giving images of objects on a scale of 1 millimetre to a minute of arc. Its great advantages would be the large region covered by a single photograph, since 5° square could be represented by it upon a plate 12 inches square. This is six or eight times the area covered by a telescopic objective. The time required to photograph a given portion of the sky would be reduced in this proportion. Such a lens, if mounted in a favourable location and kept constantly at work, would add more to our knowledge of the stars than could be obtained by a large number of telescopes of the usual kind. A telescope of this form, but of one-third its size, is now in use at Cambridge, and illustrates the advantages and amount of work which can be obtained by such an instrument. 3186 photographs have been taken with it, and from them a catalogue of 28,000 spectra of 11,000 stars has been prepared; also a catalogue of 1200 stars near the equator as standards of brightness, and a catalogue of 1000 stars within 1° of the Pole, where the most extensive existing catalogues only contain about forty stars. A search for new nebulæ was made on a small number of these plates covering about 1/250 of the entire sky. Eighteen nebulæ were already known to exist in this region. Twelve new ones were found upon the plates. These results are derived from a small portion of the entire series of plates, and much additional material will be extracted from them. The large telescope should first be used in making a map of the entire sky. All the stars north of − 30° can be advantageously photographed in the latitude of Southern California. This region, covering three-quarters of the sky, has an area of 30,000 square degrees. If each plate covered 25 square degrees, 1200 plates would be required. There are about 3600 hours of darkness in a year. Allowing one-half for clouds and moonlight, and one-third of the remainder for imperfect plates, the whole work could be done in one year, allowing an exposure of an hour to each plate. Perhaps longer exposures would be found advisable, and two years should be assigned to this work. An equal time should be spent in repeating the work, since it is essential that every part of the sky should appear on at least two plates, to verify all supposed discoveries. By using a prism to cover the lens the spectra of all the stars may be taken in the same way and in the same time. When this work is completed, it should be repeated, since we ought to have a complete map of the sky at intervals of about five or ten years in order to detect changes. Moreover, the improvement in photographic processes would perhaps be so great that a second series of plates would be desirable. The recent applications of erythrosin and other coal-tar products to photographic plates render them much more sensitive to red and yellow light. The difficulty of photographing satellites, asteroids, comets, nebulæ, and red variable stars may therefore be diminished.

The telescope should be mounted in a place having the best possible climatic conditions, preferably on a mountain where the air is as clear and steady as possible. No work need be done there except taking the photographs and developing them. Accordingly, the work might be done by a single observer; but, to avoid interruptions due to illness or accident, at least two would be required. Since their duties would be a routine requiring only ordinary skill, such services would not be expensive.

The results would take the form of a series of glass photographs about a foot square, each of which would depict all the stars visible in a part of the sky 5° square. Glass positives could be made from these by direct printing, and copies could be furnished for about a dollar apiece to any astronomer desiring to discuss them. Or an edition of paper photo-engravings could be issued. A complete set of about 1200 plates could probably be furnished for about $200. This would be a very small sum compared with the cost of a telescope which would show far less. The cost of the lens should not exceed $20,000; of the prism, $5000; of the mounting, $5000; of the building, $5000; total, $35,000. A large additional sum might be spent upon a building, but the experience of modern astronomers has shown that the best results are obtained by mounting each instrument in a small detached building which will readily assume the temperature of the air. It is more difficult to estimate the current expenses. The photographic plates alone would cost $1500 annually. The total annual expenses would not be less than $5000, not including superintendence, reductions and discussion of the observations, and publications. An outlay of $50,000 would probably complete the instrument, and secure photographs of the entire northern sky. If the anticipated results are attained, this should be followed by an endowment of $100,000, which would keep the instrument permanently at work.

The faintest stars photographed with the 8-inch telescope in Cambridge are invisible with the 15-inch telescope. The inner satellites of Uranus have been photographed at Cambridge with a 13-inch lens, although they are among the most difficult test objects known. We may therefore expect that stars too faint to be detected with any other instrument might be photographed with a 24-inch lens. We thus see that any person could obtain at a comparatively small cost a map of a portion of the sky showing stars too faint for him to observe in any other way. Many investigations might be carried on by means of these plates; for instance, a search for double stars, for nebulæ, for asteroids, for variable stars by comparison of plates of the same region taken on different nights, for stars having large proper motion when we have plates repeated after a considerable interval of time. In all these cases the plate furnishes an accurate measure of the object discovered, which is often wanting in the first observation of an object by the eye. Studies of the distribution of the stars can now scarcely be undertaken in any way except by photography. The stellar spectra might lead to the discovery of planetary nebulæ, variable stars, bright-line spectra, and other interesting objects. The number of stars shown on the charts would be so vast that it would probably be impossible to catalogue them all. In some cases it is estimated that twenty or thirty thousand stars have been photographed upon a single plate. A systematic examination of all the plates for the detection of objects of interest would itself be a laborious undertaking. Such work could, however, be done at any place and time, and therefore under the most favourable conditions as regards expense. One great advantage of the work would be, not only that we could discover certain objects of a given kind, as a particular class of double stars, but that we could make our catalogue complete, and be sure that no other objects of this kind existed, which in visual work is an extremely difficult matter.

There is always danger of failure in the construction of a new instrument. This danger is diminished in the present case, since an instrument of one-third the size is already in successful operation. Moreover, the front portion of the proposed double lens should form a good photographic objective, and might be made of the reversible form, which may be used either for visual or photographic purposes. The 13-inch lens referred to above is of this form, and proves that such an instrument is entirely practicable. We should thus be able to use the telescope in three ways: for visual purposes, as a telescope having an aperture of 24 inches, and a focal length of 17 feet; as a single photographic lens of the same dimensions; and as a photographic doublet covering a large field, and having a focal length of 11 feet. The prism could be used with each of these, making really six instruments in one. The short focal length would greatly diminish the cost of the mounting, and of the dome required to contain the instrument. The difficulties from exposure to violent winds and storms would also be much less than in an instrument of the usual form.

Should the proposed plan be carried out successfully, a contribution to astronomy would be made of continually increasing value, since each year would increase the facility with which slow changes in the stars might be detected by the comparison of later photographs with those first made.

In connection with the second circular we may remind our readers that we lately referred to the fact that the Astronomical Observatory of Harvard College has received from Miss C. W. Bruce, of New York, a gift of fifty thousand dollars to be applied "to the construction of a photographic telescope having an objective of about 24 inches aperture, with a focal length of about 11 feet, and of the character described by the Director of the Observatory in his circular of November last; also to secure its use under favourable climatic conditions in such a way as in his judgment will best advance astronomical science." This, then, is a very concrete reply to the first circular.

The second circular contains full details of the instrument, which will differ from other large telescopes in the construction of its object-glass, which will be a compound lens of the form used by photographers, and known as the portrait lens. The focal length of such a lens is very small compared with its diameter, and much fainter stars can be photographed in consequence. The advantage is even greater in photographing nebulæ or other faint surfaces. Moreover, this form of lens will enable each photographic plate to cover an area several times as great as that which is covered by an instrument of the usual form. The time required to photograph the entire sky is reduced in the same proportion. A telescope of the proposed form, having an aperture of 8 inches, has been in constant use in Cambridge for the last four years, and is now in Peru, photographing the southern stars. It has proved useful for a great variety of researches. Stars have been photographed with it, too faint to be visible in the 15-inch refractor of the Observatory. Its short focal length enables it to photograph as faint stars as any which can be taken with an excellent photographic telescope having an aperture of 13 inches. The 8-inch telescope will photograph stars about two magnitudes fainter than can be taken with a similar instrument having an aperture of 4 inches. A corresponding advantage is anticipated from the increase of the aperture to 24 inches. Each photograph will be 13 inches on a side, and will cover a portion of the sky 5° square, on a scale of 1′ to a millimetre. The dimensions will be the same as those of the standard charts of Chacornac and Peters. The entire sky would be depicted upon about two thousand such charts.

In an article in the *Observatory* for August the action taken by Prof. Pickering in making the appeal for a money grant to carry out the new map is distinctly challenged on the grounds—(1) that in the appeal there was no statement made that very nearly similar work was about to be commenced by all the civilized nations of the world after most careful consideration of the whole question by the strongest gathering of astronomers that has ever been seen; (2) that Prof. Pickering suggested to the Conference the use of a telescope similar to the one he has induced Miss Bruce to supply; and (3) that there are conditions of construction and execution of such difficulty that Prof. Pickering's plan may fail altogether.

THE JOURNAL OF MORPHOLOGY—A RECORD OF PROGRESS.

WE have before us the third and concluding part of the second volume of this excellent publication. It contains five papers (260 pages) with seventeen plates (with one exception folding ones) and fifty-four woodcuts. The illustrations are most admirable, and the plates, which bear the magic names of Werner and Winter, possess an exceptional charm. While all familiar with this Journal must admit that it has, from the first, taken high rank among its contemporaries, few will have been prepared for the magnificent display of the part now under review. With respect to its get up, the editors may well-nigh defy competition, so liberally have the publishers responded to their demands. Much that is proffered is truly American, in its revolutionary and highly sensational character; but, contrary to that which so often prevails, the startling deduction is based upon a solid foundation of fact, whereby the thing becomes tolerable, and the reader's attention is arrested. A refreshing thoroughness permeates the whole, and the work teems with originality.

The senior editor and Dr. W. Patten each contribute a short paper embodying "facts and conclusions . . . . stated in advance," of papers to be published in full in forthcoming numbers of the Journal. It is in connection with these that the revolutionary element to which we have alluded is most marked; and the reader is worked into a tremor of enthusiasm by the following among other declarations:—

"The eyes (of certain leeches) are segmental in origin, and strictly homologous with the segmental sense-organs. . . . The only evidence of an eye is a single large visual cell, on either side of the head, without a trace of pigment investment. In view of these facts . . . . we can no longer regard pigment as an essential element of the leech eye. It will not do to fall back on the hypothesis of degeneration; . . . . the visual cells are here as perfectly developed as in the pigmented eyes, and the same is true of the optic nerves."

Again—

"The segmental sense-organs of the leech are identical with the lateral line organs of vertebrates," and "when we find strong grounds for thinking that the lateral line organs have served as the point of departure for the formation of gustatory, olfactory, and auditory organs, our suspicion in regard to the eyes no longer appears incredible.[1]

The paper in which the above cited statements occur is entitled "Some New Facts about the Hirudinea," and the author defines these animals as "a group, characterized by the possession of *segmental* sense-organs on the first ring of every somite." Writing of the leeches in especial relation to the progressive development of sense-organs, he tells us that "nowhere is the transition from lower to higher sense-organs so perfectly illustrated as in the leech," and he then gives us the following remarkable passage:—

"*Branchelliopsis*, *Clepsine*, and *Hirudo* reveal all the intermediate steps, beginning with the purely tactile organ; then advancing to the compound organ, in which a few of the cells have been modified to serve the purpose of vision, while the rest have retained their primitive character; and finally, culminating after a long series of progressive encroachments—the visual elements increasing gradually at the expense of the tactile—in an organ in which the original function has been entirely suppressed and a new one substituted for it."

Again, we read—

"As the metameric arrangement of these sense-organs characterizes marine as well as fresh-water and land leeches, and as they everywhere agree in certain remarkable details of number, topography, and structure, I am led to believe that the diffuse or non-metameric arrangement, exemplified in *Nephelis* and some other forms, has been secondarily acquired."

[1] Somewhat similar views have already been postulated, for the eye by Hill (*Brain*, 1888, p. 422), and for the taste organs by Beard (*Anat. Anz.* 1888, p. 879.)

Dr. Patten's "*vorläufige*" is entitled "Segmental Sense-organs of Arthropods." His concluding remarks read as follows:—

"The ventral cord and brain of Arthropods is at first composed entirely of minute sense-organs, which in Scorpions have the same structure as the segmental ones at the base of the legs. On the lateral edge of each ganglion of the ventral cord of scorpions are two of these sense-organs, conspicuous on account of their size and dark colour. In each segment of the brain are similar but still larger ones. All these sense-organs are converted into the ganglion-cells of the brain and ventral cord."

The deductions above cited involve absorbing topics of contemporary research. We eagerly await the full papers and the discussions which they will raise, in the earnest hope (on a knowledge of that which has gone before) of an amicable settlement.

Prof. A. E. Dolbear contributes a paper on "The Organization of Atoms and Molecules," in reply to the senior editor's remarks upon "The Seat of Formative and Regenerative Energy," previously noticed in these pages. The author deals only incidentally with the biological aspects of the question; he claims that

"in late years chemists have adopted the term *Chemism* in place of chemical affinity, and have given to it a greater range of proclivities, finding no difference but one of degree between it and cohesion;"

that

"chemists have not attempted to give a physical explanation of the cohesion of atoms into molecules, but have stopped with chemism, as if it were an ultimate fact or property;"

while he attempts, as his chief object, to give

"a physical explanation of chemism or atomic cohesion, and to extend it to the building up of geometrical crystalline forms."

To this paper the editor adds some trite remarks, for which, in his modesty, he asks the reader's forbearance. The editor claims that the article in question "cannot be said to come strictly within the scope" of his journal. With that we cannot agree. The physicist's view of the nature of organic phenomena is very welcome, and we are of opinion that much good would result could we replace many a purely discursive biological article with one such as this, if only with a view to a more definite agreement with the physicist than at present exists, upon a sound basis for future work.

The papers which will attract most attention are those of Minot and Allis, upon the mammalian placenta, and the lateral line system in Amia, respectively. Each is a masterly monograph: the chief interest of the first-named centres in its revolutionary character; that of the last-named in its solidity and thoroughness. Prof. Minot deals in full only with man and the rabbit, and he proceeds at the outset to supplement previous work in matters of detail. He seeks to show that "the changes in the uterus during gestation" are "a prolonged and modified menstrual cycle," and that "the ovum has no power of initiating the development of a *decidua*, but only of modifying the menstrual process; hence pregnancy *can* begin only at a menstrual period." In discussing the views of others he is dogmatical but never disrespectful, and the following may well be cited in example:—

"We know positively scarcely more than that the maternal and fœtal circulations are brought very close together in the placenta. We infer that there must be a transfer of nutritive material from one blood to the other. As to *what* material is transferred and *how*, we have only theories, but of them an abundance. Under these circumstances, the best beginning is undoubtedly a frank acknowledgment of our ignorance."

The author contends that "we are brought squarely to the conclusion that the fœtal placenta is chorionic," and that "from this premise phylogenetic speculation must start." He tells us that, "so far as our present knowledge enables us to judge, the discoidal is probably the primitive placental type." With this we heartily agree, and it has always appeared to the writer of the present article that the same conclusion is, on the Balfourian hypothesis (from which Prof. Minot dissents) that both the yolk-sac and allantois were primitively concerned in rendering the chorion vascular, by far the most natural one warranted by the facts. The belief in the primitive nature of the diffuse placenta is, beyond doubt, largely attributable to its non-deciduous character. With Dr. Minot, we are opposed to Ryder's theory of the "origin of the discoidal placenta by constriction of the villous area of the zonary placenta." We would rather reverse the order, and regard the zonary type as transitional between the more primitive discoidal one and the more recent and modified diffuse cotyledonary and metadiscoidal varieties, regarding the replacement of the discoidal in the zonary type as primarily due to extension consequent upon the complete withdrawal of the yolk-sac from the chorion. Under this hypothesis the simple nature of the villi of the diffuse placenta might well be considered secondary.

Dr. Minot's paper furnishes a moral which cannot be too often borne in mind, viz. that it is not necessary to look beyond the most familiar organisms for material for legitimate work: neither a "new body" nor "a hitherto undescribed organism" are indispensable to the building up of a reputation.

Mr. Allis's paper is one for which we have eagerly watched, it being (as our readers will be aware) the first of a promised series. The author maps and classifies the sense-organs of the head with minute accuracy, at the leading stages of growth. When he tells us that "as many as thirty-seven hundred" pores "were counted on the head of a single large specimen," some idea of the laboriousness of his task may be formed; and on finding that he has worked out the detailed relationships of the parts to the individual bones, that he has, in addition to working out their development, determined the limits of individual variation and taken count of abnormalities, it is clear that his labour is a labour of love. The thoroughness of his work and the beauty of his illustrations must be seen to be appreciated; and should he complete his task, maintaining the standard of excellence with which he has started, he will have merited the regard of biologists for all time. He has brought to light the surprising fact that many of the first formed openings of the cutaneous canal system fuse to form pores, and that the dendritic systems and groups of pores which, in the adult, replace these, arise to a large extent from their repeated dichotomous division.

The author deals neither with polemics nor generalities,[1] nor does he even allude to striking facts which his figures show, foreign to his immediate inquiry. Consideration of these is doubtless deferred. He deals incidentally with the neuro-epithelium of the spiracular cleft discovered by Wright; this he regards as a sense-organ, which was "regularly developed in the epidermal covering of the head along with the other organs of the infra-orbital line, but, lying near the edge of the spiracular cleft, it wandered into this cleft as it was closed." Indeed, it is upon this observation that the author's co-editor confessedly bases his belief in the migratory origin of the gustatory organs; and Mr. Allis's allied discovery that "the nasal pits are inclosed in the same way that the lateral canals are" will be welcomed with especial interest by embryologists of the hour.

We have often wondered that our American brethren should have been so tardy in working out the structure and development of their native *rarissima*. Their Opossum and their Urodeles are now receiving attention, a beginning has been made with Lepidosteus, the Gymnophiona remain. Zoologists of the Old World could desire nothing better at the hands of their New World *confrères* than a series of exhaustive monographs upon the structure and development of the animals named, uniformly with the one now under review. A better model of conscientious work it would be difficult to produce.

G. B. H.

[1] He appears to have overlooked an important paper by Fritsch, in *Stzb. Berlin Akad.*, 1888, viii., p. 273.

THE AUGUST PERSEIDS OF 1889.

THE moon being full on the morning of August 11, it was hardly to be expected that the Perseid meteors would exhibit a notable display this year. Apart, however, from the ill effect the moonlight must certainly have exercised upon the visible character of the shower, there is no doubt that the phenomenon has proved one of minor importance. I have never observed, during the previous twenty-two years, so scanty a fall of the August meteors.

I made observations on July 26, 27, 29, 30, 31, and August 3, for the express purpose of determining the radiants of early Perseids, but failed to secure an adequate number of paths to carry out that intention. In watches extending over eleven hours I counted 89 meteors, but not more than 6 of these could have been Perseids. It was evident that this system was very feebly represented. Yet in 1887 it formed a very distinct and fairly active display as early as July 19 and 22, and I have sometimes remarked decided traces of it in the second week of July. In 1878 and several other years I observed that the Perseids made a prominent shower towards the close of that month, and it was easy to find the position of its radiant on every clear night. But this has been quite impracticable in 1889, owing to the exceptional scarcity of mteors.

On August 7, 1889, I looked towards the eastern region of the firmament during the $2\frac{1}{2}$ hours from $11\frac{1}{2}$h. to 14h., and recorded 28 meteors only. Amongst these were 10 Perseids with a radiant point very sharply defined at $41° + 58°$. They were rather small and traversed short paths; nearly all of them appeared near the centre from which they radiated. The shower was, however, of greatly inferior character to what was expected on a date so near the maximum. The ensuing nights were pretty clear, but in the brilliant moonlight meteoric apparitions were very infrequent. On August 10 only 8 Perseids were noticed in one hour before midnight.

My recent observations would seem to indicate that we have passed through a minimum of the August meteors.

The Aquarids which are generally very abundant at the end of July were also weakly displayed this year. I registered 6 of them between July 27 and August 3, from a radiant at $336° - 13°$. Of the other streams which distinguish this epoch I saw several, the principal of them being a shower of Cepheids from $329° + 62°$ and of Cassiopeids from $8° + 52°$.

W. F. DENNING.

NOTES.

WE print to-day the Report of the Committee appointed by the Treasury on the Scientific Collections at South Kensington under the control of the Science and Art Department. It is some seventeen years since the Duke of Devonshire's Commission recommended their formation, and it would seem now that something may really be done after so long a delay. The Committee, it will be seen, discuss both the question of a new building and that of the proper organization of such collections. The eminence of the members of the Committee adds great weight to their recommendations, and the Report has been very favourably received by the Press.

THE meeting of the Iron and Steel Institute in Paris on the 24th and following days of September promises to be of great interest. A large attendance of members is expected. They will be received and entertained by an influential committee under the presidency of M. Eiffel; and the French Society of Civil Engineers will entertain them at breakfast on the Eiffel Tower. Among the papers will be one by Sir Lowthian Bell on the subject of water gas, and Prof. Jordan will deal with the mining and metallurgical exhibits at Paris. Excursions will be made to the iron-works of the Loire and St. Etienne, and of the Nord, and to other centres of the iron and steel industry. Luxembourg and the works of M. Schneider at Creusot will also be visited.

PROF. LÖWIG has resigned his appointment as Director of the Chemical Laboratory at the University of Breslau. He has seen nearly sixty years of academical service.

A SEVERE shock of earthquake was felt in Greece on August 26. According to a Reuter's telegram from Athens, the direction of the earthquake was from north-west to south-east. Its effects were most severe in the district of Acarnania. Most of the houses in the towns of Amerinion and Aetolikon have become uninhabitable, and chasms were formed emitting sand and water. The centre of the shock is believed to have been in the Gulf of Corinth, where the telegraph cable was broken.

THE National Home-Reading Union has now opened its office at Surrey House, Victoria Embankment, W.C. Miss Mondy has been appointed Secretary to the young people's section, and Mr. George Howell, M.P., Secretary to the artisans' section. All communications concerning either of these sections should be addressed to them respectively. Miss Mondy has also been appointed Office Secretary, and communications concerning the general work of the Union, as well as concerning the general readers' section, should be addressed to the Hon. Secretary. Letters of inquiry should be accompanied by a stamped and addressed envelope.

THE *Victorian Naturalist* for May and June contains a most interesting paper, by Prof. Baldwin Spencer and Mr. C. French, describing a trip through the district of Croajingolong. Speaking generally, they describe West Croajingolong as composed of Lower and Upper Silurian strata—slates, shales, sandstones, more rarely conglomerates, and at times metamorphosed by contact with irruptive rocks. The latter are in the form of (1) continuous bands of granite, or (2) a series of knobs of granite, both running along lines lying roughly north and south. In the former case they are traversed along their length by river-valleys. In districts where there are isolated knobs of granite, the rock masses stand out, forming prominent peaks and ridges. The weathering of the granite on Mount Ellery is described as most striking. On the surface it has been formed into huge boulders from 20 feet to 75 feet in height, which lie piled up on one another in indescribable confusion. One huge mass, the egg shape of which gave to the mountain the native name of "Goonegerah," stands out high above the dense forest, which, save in this instance alone, clothes to their summits the long ridges and many peaks of this wild district. So far as the insect life of the district is concerned, the most striking phenomenon seems to be the vast number of ant-hills in every part. Over large areas the mounds of "jumper" ants were so thick as to remind the travellers of "mole-hills" at home. In their study of the flora of Croajingolong they were most impressed by the numerous specimens of the cabbage-tree palm (*Livistona australis*) and the waratah (*Telopea oreades*). The existence of the latter species, peculiar to Victoria, was first discovered by Baron von Mueller during his journeying through the Genoa district in East Croajingolong. This tree, which sometimes reaches the height of 50 feet, grows with equal profusion and strength in the deepest valleys and on the tops of the loftiest hills.

THE Board of Regents of the Smithsonian Institution have issued Part 1 of the Annual Report, showing the operations, experiments, and condition of the Institution, for the year ending June 30, 1886. A general appendix contains papers relating to anthropology, by various writers; a paper on certain parasites, commensals, and domiciliares in the pearl oysters, by R. E. C. Stearns; a paper on time-reckoning for the twentieth century, by S. Fleming; a report on astronomical observatories, by G H. Boehmer; and a catalogue of publications of the Smithsonian Institution, by W. J. Rhees.

MR. J. H. HART, Superintendent of the Botanic Gardens, Trinidad, refers, in his Report for 1888, to the comparatively large number of American and European tourists by whom these gardens are now visited. Mr. Hart has been more impressed by the energy and enthusiasm displayed by visitors from the north than by "anything seen from the European side of the world." "In fact," he says, "Europeans must look to their laurels in these matters. Speaking as one myself, it cannot be said that any prejudice dictates this expression of opinion, but I record it as a fact worthy of the attention of my countrymen." Tourists of all classes at Trinidad, it seems, agree in one respect—in their love of photographing forms of plant life which are new or strange to them. Mr. Hart is so unkind as to describe this as a "prevailing epidemic." The expenditure of dry plates in the Trinidad Gardens is "so large as to afford a rich harvest to the manufacturers."

THE Committee of the Chester Society of Natural Science and Literature has issued its Report, with statement of accounts, for 1888–89. This Society was founded by Charles Kingsley in 1871, and has made steady progress in every department of its work. It has now 617 members. Originally, it included only three sections; now there are seven, "with the prospect of an eighth in the coming year." During the past year the debt on the present building was entirely wiped out through the liberality of some of the members, and the Society looks forward with satisfaction to an increase of accommodation.

A PAPER on the soft palate in the domestic cat, by Dr. T. B. Stowell, has been reprinted from the tenth volume of the Proceedings of the American Society of Microscopists. It is offered as a preliminary contribution to a more general inquiry "as to the phylogenesis and the function of the uvula of the palate, or the conditions which favoured or led to the uvula of the palate, or the conditions which favoured or led to the development of the uvula of the soft palate." On March 2, 1888, the same writer read before the American Philosophical Society, a paper on the glosso-pharyngeal, the accessory, and the hypoglossal nerves in the domestic cat. This paper has also been issued separately.

La Nature of August 17 contains an interesting account, by M. Angot, of the laboratories and instrumental arrangements of the Central Meteorological Office in Paris, which now occupies a large building and grounds formerly connected with the Emperor's stables, with an entrance in the Rue de l'Université. The building is lighted, when required, by electricity, and contains, in addition to the usual offices, several rooms for the verification of instruments, of which a great number are tested annually, darkened chambers for the photographic registration of earth currents and magnetic elements by instruments designed by M. Mascart. These instruments are influenced by surrounding buildings, and are principally intended for the instruction of visitors; the more accurate records are made at the Observatory of the Parc St. Maur. Another large room is devoted to the apparatus invented by M. Weyher for reproducing atmospheric whirls artificially. In the grounds are evaporation tanks, and a platform for anemometers of various descriptions; the records of one of Richard's sensitive instruments are compared with a similar instrument on the Eiffel Tower, and it is said that the comparison has already led to some interesting results; the platform also contains an actinometer on M. Violle's principle, with two spheres, one blackened and the other gilded. It is intended to erect in the garden a whirling machine for anemometer experiments, having a circumference of 40 mètres, with a maximum motion, by electricity, of one revolution per second, which is equivalent to about 90 miles per hour.

Das Wetter for August contains the first part of a lecture by Dr. W. Köppen, entitled "Biological Considerations upon Cyclones and Anticyclones." He points out that the word cyclone was first proposed by Piddington, in his "Sailor's Horn-Book," in 1848, to describe the violent hurricanes of the tropics, in which the wind rotates, in the northern hemisphere, in a direction opposite to the hands of the watch. The term anticyclone was first used by Mr. F. Galton, in his "Meteorographica," in 1863, to represent the opposite class of atmospheric disturbance, in which the wind circulates in the same direction as the hands of a watch. The use of synoptic charts, with isobaric lines, drawn for large areas, shows that the same cyclonic motion occurs in our latitudes, in all degrees of force, down to a gentle breeze. This constitutes one of the most important discoveries of modern meteorology, which dates from about the year 1860. The author points out that the circuitous motions of the atmosphere, whether cyclonic or anticyclonic, consist of three component parts, which can be proved by the laws of mechanics, viz. one rotating motion, one in the direction of the radius, and one perpendicularly to both of these, parallel to the axis of the whirl. The behaviour of the atmospheric motions in the higher regions is more difficult to describe, but so much seems certain from observations of clouds, &c., that the rotation is similar to that below, but the component falling in the direction of the radius is the opposite to that below, viz. an indraught below corresponds to an outflow above. He explains the more frequent gyration of the wind-vane to the right than to the left by the fact that stations in our parts are generally to the right of the storm-areas. He also shows how the ascending current of cyclones produces cloud and rain, by cooling and condensation of vapour, and how the descending current in anticyclones produces dry and bright weather. The remaining article is a discussion by Dr. Kremser, of the extraordinarily high temperatures in North Germany during May and June last. He has compared the daily temperatures of the last forty-two years with those for 1889, and shows the result in a diagram; from which it is seen that for the whole period (April 19–June 20) the temperature was on an average 9° above the normal value. The author states that the Berlin observations, which date back to 1719, show that no May has been so warm, and that the temperature of June has only once been slightly higher, viz. in the year 1756.

Mr. Edward Stanford has published a little volume containing useful "Algerian Hints for Tourists," by Mr. Charles E. Flower. The writer intends that it shall be used as an appendix to the guide-books. He tells his readers what there is in Algeria to see, and "how to get to see it." For further information they are directed to the guide-books properly so called.

We have received Parts 11 and 12 of the Transactions of the Leicester Literary and Philosophical Society. Part 12 includes the Report of the Council, and the Annual Reports of the Sections, presented to the general meeting on June 24.

Messrs. George Philip and Son have issued, in two sheets, an excellent topographical map of the Riviera. It has been published by A. Donath, in Genoa.

The Calendar of University College, Dundee, for the seventh session, 1889–90, has been issued. University College, Bristol, has also published its Calendar for the session 1889–90. In a prefatory note attention is called to the fact that the Bristol College particularly affords appropriate instruction in those branches of applied science which are more nearly connected with the arts and manufactures.

"Flowerland," an introduction to botany, by Robert Fisher, is about to be issued by Messrs. Bemrose and Sons. The work includes 150 illustrations.

At a recent meeting of the Vaudois Society of Natural Sciences, Prof. Blanc gave some interesting information about lake trout reared at the agricultural station of Champ de l'Air. The peculiarity of the experiment was keeping the ova in complete darkness throughout the time of incubation. The water used had a temperature of 4°·8 C. Prof. Blanc compares the experiment with one at Moudon. There, with a temperature of 2°·3, the hatching occurred after 145 days. At Champ de l'Air (temperature 4°·8), it occurred after 160 days, a difference of 15 days, due to the darkness. There are sundry advantages in prolonging the incubation: (1) the young fry put into the streams in April or May more readily find food than in February or March; (2) they are found to be more vigorous; (3) there are few or no monstrosities.

Some curious facts bearing on the *morale* of the lower animals are given by a correspondent of the *Revue Scientifique*. One source of animal sociability is a permanent sexual friendliness, making individuals mutually agreeable. Thus in stables without stalls, it is desirable to put animals of opposite sex next each other, to avoid injuries. A mare may be safely put into a field containing a horse unknown to it, but if two unacquainted horses be thus put together they will fight. A stallion, indeed, will sometimes get injury from an unknown mare put into a field with it. Again, the authority of the oldest and strongest in a group of males often favours sociability. In the Spanish *ganaderias*, a horseman will lead about a numerous troop of bulls, by means of five or six bulls who obey him and maintain order. In the Madrid circus the writer saw three of these animals bring to its stall a vicious bull which had ripped up five or six horses and mortally wounded its *Espada*. They made a slight movement of the horns, and the creature, after a little hesitation, turned and followed them. Once more, when flocks of wild ducks and geese have to go long distances, they form a triangle to cleave the air more easily, and the most courageous bird takes position at the forward angle. As this is a very fatiguing post, another bird, ere long, takes the place of the exhausted leader. Thus they place their available strength at the service of the society.

The attention of the French Government has recently been drawn to the destruction of small fish, especially flat-fish, round the coasts, by shrimp trawls, and the question was referred to the French Fisheries Committee to be inquired into. The Committee have now published their report, in the *Journal Officiel*, in which they recommend the entire prohibition of fishing for shrimps with trawls, and advocate in its place the adoption of two other methods which were brought to their notice at Croisic and at Saint Gilles, where they are already in practical use. At Croisic the engine consists of a trap, somewhat on the principle of an ordinary lobster-pot; it is a wooden frame, in shape like a barrel, and about 2 feet 6 inches long, covered with a small meshed net drawn in at the ends, thus forming two funnels. Each funnel terminates in a small opening through which the shrimps are attracted by bait suspended inside the trap. The machine, which is weighted with stones made fast to the frame, is further provided with a mooring line, and cork float. These traps, of which each fisherman may own from twenty-five to thirty, are kept permanently on the fishing-grounds during the shrimping season, and are visited daily, when the catches are taken out through a hinged opening at the side, and fresh bait put in. The second method recommended consists of a conical pocket of small meshed net about 18 inches deep, fixed to an iron ring with a diameter of 2 feet 6 inches to 3 feet. Four short lines are attached to the ring, and are made fast to a rope and cork float. The bait, which consists of bits of fish, is either placed at the bottom of the pocket or on two lines stretched across the iron ring. These nets require to be raised every 15 or 30 minutes; they should be sunk so that the ring just rests on the bottom, the supporting lines being kept clear of the bait by means of a float fastened at the junction of the lines with the mooring rope. This method is said to be most successful when carried on at low water in the early morning.

A RECENT number of the *China Review* (vol. xvii. No. 3) contains a paper by Dr. Macgowan on the alleged avenging habits of the cobra in Indian and Chinese folk-lore. The belief in India is that a wounded cobra which escapes will sooner or later revenge itself on the man who has caused the injury, wherever he may go or whatever he may do. Dr. Macgowan says that this belief is prevalent in Indo-China and China as well as in India. But in China there is also a strong prejudice against killing the cobra, lest its spirit should haunt the slayer ever after. Cobras, therefore, are shunned rather than pursued and attacked. Popular stories of the dire consequences of slaying them keep up the superstition: a high official who had killed one died soon afterwards of some mysterious disease, and the death is attributed to the slain snake; again, the spirit of the snake enters into possession of its slayer, and employs the vocal organs of the latter in uttering imprecations on himself until death mercifully removes him. Dr. Macgowan gives a large number of stories of this character. A number of others refer to the retribution on snake-killers after their own deaths. Gratitude, as well as vindictiveness, is ascribed to snakes, of which some characteristic stories are given. In conclusion, Dr. Macgowan observes that the recently established vernacular press in China furnishes inexhaustible stores of folk-lore. "Paragraphs describing popular superstitions, impossible occurrences, monstrosities, and so forth, constitute a great portion of their matter." In regard to snakes, the marvel is that any are killed at all in China, so many dreadful punishments are supposed to overtake their destroyers; and, indeed, it is considered a work meriting favour here and hereafter to purchase captured snakes and liberate them. Nevertheless, poisonous snakes are not numerous in China, probably because their presence is inconvenient to Chinese farmers, and they are therefore destroyed, folk-lore notwithstanding.

IN connection with the recent discussion, in Parliament and elsewhere, respecting emigration to South America, it may be interesting to reproduce certain observations of Dr. Alfredo da Luy, at a late meeting of the Academy of Medicine at Rio, on the effect of climate on race. They are quoted in a report from the British Legation in Brazil, which has recently been published. "I have long noticed," he says, "that Brazilians in general are more pallid, and are less vigorous and energetic, than persons coming from temperate and cold climates. Here in Rio de Janeiro the degeneration of the Portuguese race may also be noted. In fact such inhabitants of Rio de Janeiro as are not coloured persons are generally pallid, weak, of short stature, and of but little muscular strength. I have found that an anæmic condition is very common among us, and, in most cases in our country, malarious infection is the cause of the impoverishment of blood, whenever this impoverishment exceeds physiological limits. I believe, however, that such malarious impoverishment of blood seldom kills by itself, but this it is which makes children in Rio de Janeiro show so little resistance to other maladies, and it is one of the causes which concur to produce the great infant mortality in the city of Rio de Janeiro. The average annual mortality of children in Rio de Janeiro, up to seven years of age, was 2900 in the five years from 1882 to 1886, excluding those born dead. It is chiefly among the children of Europeans resident in Brazil that I have met with the most accentuated impoverishment of blood and debility, and I believe the explanation to be marshy malaria (*impaludismo*). I have noticed in my practice that the children of Portuguese and Italians do not fare so very badly in the Brazilian climate, but that the children of foreigners coming from the north of Europe show a noted physical degeneracy, and a frail vital resistance, so that the greater part of them succumb at a tender age, and even if they reach adult life they never show any grade of robustness and energy comparable to that of their progenitors. Although I am fully persuaded of the good moral qualities of the European colonist, I think it my duty to state that Germans, French, Belgians, and other persons from climates very different from ours, will never be able to give a prosperous colonization to our warmer provinces, except in the case of crossing with races better adapted to hot climates."

IN Consul-General Playfair's Report to the Foreign Office on the agriculture of Algeria, it is said that viticulture in that country is beset with many dangers. In spring, hailstorms frequently destroy the young shoots; the flowers are often ruined by fogs; and the ripe fruit by the sirocco. The most serious enemy is, of course, the *Phylloxera*, but the officials have been fairly successful in dealing with this pest. Another is the *altise*, a small beetle that causes great destruction, particularly when in its larval condition. The mode of killing the *altise* commonly adopted is to place bundles of grass and vine-cuttings around the vineyard when winter is approaching; in these the insects conceal themselves in large compact masses, and the whole is then set on fire. Other diseases are the *oïdium*, *anthrachnosis*, *peronospera*, and *chlorosis*. It is calculated that the want of intelligent treatment of these diseases causes the owners of the vineyards to lose annually nearly a third of the crop. The olive seems to grow everywhere in Algeria except in marshy ground, and attains dimensions quite unknown on the northern coast of the Mediterranean. At present, however, from careless cultivation, the plant has not proved as remunerative, nor have its products been as good, as in Europe.

THE British Consul at Bogota, in his last Report to the Foreign Office on the agricultural condition of Colombia says that for tobacco cultivation in that country no manure is used, and the same land is used over and over again for an indefinite number of years. In some districts, where disease has completely exterminated the tobacco plantations, it has been found that when plants are brought from other districts they are not attacked for a few years, but ultimately they are also destroyed. This, perhaps, might be avoided by constantly importing fresh seed; but the experiment was tried on some of the best tobacco land in Colombia, with the result that as the seed brought from inferior districts began gradually to improve by transportation to the better soils, it became more liable to disease, while the plants grown from seeds brought from the better districts were attacked at once. Another instance of the ignorance of scientific agriculture in Colombia appears in the case of cocoa. It is most carelessly cultivated, though it is a crop which requires constant care and labour to weed and clean the ground, and free the trees of the numerous insects, especially the caterpillars, which infest them. A most destructive disease has lately attacked the trees in the south of the Tolima, which is one of the very richest districts in Colombia. This disease does not seem to have been investigated, and no remedy has been suggested, but the extent of its ravages will be understood from the fact that one of the plantations attacked produced only 175 pounds instead of 18,000 pounds of cocoa.

THE additions to the Zoological Society's Gardens during the past week include a Formosan Deer (*Cervus taëvanus* ♂), a Japanese Deer (*Cervus sika* ♀) from Japan, two Three-striped Paradoxures (*Paradoxurus trivigatus*), a Great Eagle Owl (*Bubo maximus*) from China, presented by Capt. C. Taylor s.s. *Aberdeen;* a Common Fox (*Canis vulpes* ♀), British, presented by Mr. Edward Hall; a Bewick's Swan (*Cygnus bewicki*) from China, presented by Mr. Jansen; a Peregrine Falcon (*Falco peregrinus*) from Cyprus, presented by Dr. W. Hoad; a Mantchurian Crane (*Grus viridirostris*) from North China, eighteen Spanish Blue Magpies (*Cyanopolius cooki*) from Spain, an Indian Python (*Python molurus*) from India, two Water Rattlesnakes (*Crotalus adamanteus*) a Mocassin Snake (*Tropidonotus fasciatus*) from North America, deposited; five African Lepidosirens (*Protopterus annectans*) from the River Gambia, West Africa, purchased; a Royal Python (*Python regius*) from West Africa, received in exchange; an Indian Muntjac (*Cervulus muntjac* ♂), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

COMET 1889 *d* (BROOKS, JULY 6.)—The following elements and ephemeris for this object are by Herr Otto Knopf (*Astr. Nach.*, No. 2916):—

T = 1889 July 12·2616 Berlin M.T.

$$\left.\begin{aligned} \pi &= 330^\circ\ 7'\ 5'' \\ \Omega &= 29\ \ 4\ 56 \\ \iota &= 5\ 44\ \ 7 \end{aligned}\right\} \text{Mean Eq. } 1889{\cdot}0.$$

$$\log q = 0{\cdot}35280$$

Error of middle place (O − C).
$d\lambda \cos\beta = +20''$; $d\beta = -2''$.

The observations on which these elements are based were obtained at Lick, July 8; Vienna, July 21; and Dresden, July 30.

Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
Aug. 31	0 7 30	5 53·2 S.	0·3665	0·1326	1·37
Sept. 4	0 6 29	5 48·4	0·3686	0·1324	1·36
8	0 5 14	5 43·8 S.	0·3709	0·1333	1 34

The brightness on July 8 is taken as unity.

On August 1, Mr. Barnard observing at the Lick Observatory, found the comet to be composed of three distinct adjacent comets, perhaps more; and Prof. Weiss, under date August 6, reported it as fourfold.

COMET 1889 *e* (DAVIDSON).—Dr. Becker gives the following elements and ephemeris for this comet, derived from observations made at Rome on July 26, Vienna on August 4, and Dun Echt on August 15.

T = 1889 July 19·29538 G.M.T.

$$\left.\begin{aligned} \pi - \Omega &= 345^\circ\ 53'\ 6''{\cdot}9 \\ \Omega &= 286\ \ 8\ 16{\cdot}2 \\ \iota &= 65\ 59\ 59{\cdot}7 \end{aligned}\right\} \text{Mean Eq } 1889{\cdot}0.$$

$$\log q = 0{\cdot}016949$$

$\Delta\lambda \cos\beta = +6''{\cdot}6$; $\Delta\beta = -0''{\cdot}3$; (O − C).

Ephemeris for Greenwich Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log Δ.	Log *r*.	Brightness.
Aug. 28	16 9 43	24 8·2 N.	9·9432	0·0919	0·12
Sept. 1	16 18 58	25 47·5	9·9794	0·1043	0 10
5	16 27 38	27 9·7	0·0125	0·1170	0·08
9	16 35 53	28 18·8	0·0429	0·1299	0·06
13	16 43 49	29 17·6	0·0708	0·1428	0·05
17	16 51 34	30 8·2	0·0966	0·1557	0·04
21	16 59 12	30 52·3 N.	0·1205	0·1686	0·04

The brightness on July 22 has been taken as unity.

NEW MINOR PLANETS.—Two new minor planets were discovered on August 3; the one, No. 285, by Herr Palisa at Vienna, the other, No. 286, by M. Charlois at Nice.

NEW DOUBLE STARS.—Mr. Burnham reports that η Ophiuchi is a close double, the two components being of nearly equal magnitude. The present position of the fainter is angle = 274°·7, and distance = 0″·35. It will probably be found to be a binary of somewhat short period.

θ Cygni has a small companion at position-angle 43°·9, and distance 3″·62, recently discovered by Mr. Burnham. The companion is about the fourteenth magnitude.

STARS WITH REMARKABLE SPECTRA.—The examination of the photographs of stellar spectra taken at Harvard College in connection with the Henry Draper Memorial has shown DM + 43° No. 3571 to have a spectrum crossed by bright lines, and similar to those of the three stars discovered by Wolf and Rayet in 1867. Two other stars, DM + 66° No. 878, and DM + 84° No. 516, especially the latter, have the most strongly marked spectra of Secchi's third type which have yet been recognized, except in the case of some variables of long period.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 SEPTEMBER 1–7.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 1

Sun rises, 5h. 15m.; souths, 11h. 59m. 46·7s.; daily decrease of southing, 18·9s.; sets, 18h. 45m.: right asc. on meridian, 10h. 43·1m.; decl. 8° 8′ N. Sidereal Time at Sunset, 17h. 30m.

Moon (at First Quarter September 2, 20h.) rises, 11h. 59m.; souths, 16h. 50m.; sets, 21h. 31m.: right asc. on meridian, 15h. 33·9m.; decl. 15° 29′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	7 10	13 14	19 18	11 58·0	0 5 N.
Venus.....	1 33	9 23	17 13	8 6·4	19 33 N.
Mars......	2 59	10 33	18 7	9 16·1	17 5 N.
Jupiter....	15 16	19 9	23 2	17 53·6	23 26 S.
Saturn....	3 54	11 11	18 28	9 54·1	14 1 N.
Uranus...	9 3	14 30	19 57	13 13·9	7 12 S.
Neptune..	21 39*	5 29	13 19	4 11·7	19 26 N.

* Indicates that the rising is that of the preceding evening.

Sept.	h.	
4	2	Jupiter in conjunction with and 1° 2′ south of the Moon.
7	8	Neptune stationary.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
S Arietis	1 58·7	12 0 N.	Sept. 1,		*M*
R Arietis	2 9·8	24 32 N.	,, 7,		*M*
R Ursæ Majoris	12 31·3	60 6 N.	,, 5,		*M*
R Boötis	14 32·3	27 13 N.	,, 2,		*M*
δ Libræ	14 55·1	8 5 S.	,, 5,	0 22	*m*
U Coronæ	15 13·7	32 3 N.	,, 3,	2 1	*m*
U Ophiuchi	17 10·9	1 20 N.	,, 3,	0 46	*m*
			,, 3,	20 54	*m*
X Sagittarii	17 40·6	27 47 S.	,, 2,	1 0	*M*
W Sagittarii	17 57·9	29 35 S.	,, 2,	22 0	*M*
Y Sagittarii	18 14·9	18 55 S.	,, 1,	1 0	*m*
β Lyræ	18 46·0	33 14 N.	,, 4,	23 0	m_2
R Lyræ	18 52·0	43 48 N.	,, 5,		*M*
U Aquilæ	19 23·4	7 16 S.	,, 5,	2 0	*m*
T Vulpeculæ	20 46·8	27 50 N.	,, 1,	0 0	*M*
δ Cephei	22 25·1	57 51 N.	,, 3	23 0	*m*

M signifies maximum; *m* minimum; m_2 secondary minimum.

Meteor-Showers.

	R.A.	Decl.	
Near ρ Persei	43	39 N.	Swift; streaks.
,, 33 Cygni	305	55 N.	Swift; bright.
,, γ Piscium	347	0	Slow; bright.

THE SCIENCE COLLECTIONS AT SOUTH KENSINGTON.

THE following is the Report of the Committee appointed by the Treasury to inquire into the Science Collections at South Kensington :—

1. Our original instructions are contained in the Treasury Minute of the 19th February 1889, which will be found in the Appendix (No. 1). Upon consideration, we found that some amplification of these instructions were necessary, and we accordingly communicated to Government the resolution which is printed in the Appendix (No. 2). In reply to this resolution we received a letter from the Treasury under date of the 23rd March, Appendix (No. 3).

2. After some preliminary deliberation, and an inspection of the collections which form the subject matter of our inquiries, we proceeded to take evidence from representatives of the Science and Art Department and others who had been practically concerned in the formation and arrangement of these collections ; and, during our inquiries, we have again inspected the several branches of the Museum in company with professors of the Normal School of Science and others specially conversant with the contents of each ; we have also been furnished with detailed catalogues of the collections. By these means we trust that we have secured an acquaintance with the contents of the science collections sufficiently exact for the purpose of our present inquiry.

3. It may be convenient that we should recapitulate the different collections with which we have had to deal, noticing at the same time the manner in which they are at present housed. In these respects, the changes since Sir Frederick Bramwell's Committee reported have been not inconsiderable.

The collections have been classified by the Department (January 1888) under two main divisions :—

I. Instruction and Research.

II. Industrial Applications.

Division I.—The collection of Scientific Instruments and Appliances for science teaching occupies 6325 square feet on the ground floor and 15,840 square feet on the upper floor (in all 22,165 square feet) of the Western Galleries.[1]

It is grouped by the Department under the following heads, corresponding in the main with the arrangement of the Science Directory.

A.—Mechanics and Mathematics.

B.—Physics.

C.—Chemistry, Metallurgy, and Principles of Agriculture.

D.—Biology.

E.—Geology, Mineralogy, and Mining.

F.—Navigation, Nautical Astronomy, and Physiography.

The collections illustrative of Mining are, however, housed in the Geological Museum in Jermyn Street, in connection with the Royal School of Mines. These we have not examined or considered.

Division II.—Industrial Applications.

(*a*) The collection of Machinery and Inventions (including the selected specimens from the old Patent Museum, and also some few illustrations of metallurgical operations) occupies 18,476 square feet on the ground floor of the "Southern Galleries."[2]

(*b*) The collection illustrative of Naval Architecture and Machinery occupies 15,374 square feet in all on the upper and ground floors of the "Southern Galleries," the machinery being on the ground floor.

(*c*) The Fish Culture collections and some miscellaneous objects occupy 5630 square feet in a wing at the west end of the "Southern Galleries."

4. In addition to these branches of our subject we should, in order to complete the list of scientific collections, mention the two following, which lie beyond the terms of our reference :—

(i.) The Educational Library of Science. This is now placed in the Museum, to the east of Exhibition Road, in connection with the Art and General Library.

(ii.) The collections of Food and Animal Products, formerly at South Kensington. These are now housed in the Bethnal Green Branch Museum.

It may be convenient to add that about 16,000 square feet on the two floors of the eastern end of the Southern Galleries (formerly the National Portrait Gallery) are now occupied by a collection of modern industrial products, furniture, and ornaments, removed thither from Bethnal Green, which belongs to the Art division of the Museum, and has no connection with the Science collections upon which it is our duty to report. Further, about 9200 square feet on the ground floor of the Western Galleries are used only for examination rooms.

[1] The Western Galleries are those adjoining Queen's Gate and north of the new Imperial Institute Road.

[2] The Southern Galleries are those extending from Exhibition Road to Queen's Gate to the south of the new Imperial Institute Road.

5. It will be observed that in our enumeration of the branches of the Science Collections as at present existing, we have made no reference to two branches mentioned in the Report of Sir F. Bramwell's Committee :—

(*a*) The Educational Collection.

(*b*) The Structural Collection.

For these sections spaces of 7000 square feet and of 15,000 rising to 25,000 square feet respectively, were demanded by the Committees whose recommendations were adopted in that Report.

These sections have been suppressed for reasons given by General Donnelly, the articles of which they were composed having been returned to the lenders or otherwise disposed of. It was probably the aspect of these collections which, upon a superficial view of them, led to the severe strictures sometimes passed on the contents of the Southern Galleries.

As regards these two sections, we may here say that in our opinion the necessity for the exhibition of school furniture and fittings, such as are required for schools receiving grants under the Elementary Education Acts, no longer exists ; but (under proper limitation) a series of diagrams and models of the best forms of construction and a collection of specimens of material, specially designed for scientific and technical education, might with advantage be exhibited in connection with the subject of mechanics as taught in the Norman School, and with that subject and with building construction as taught in science classes, and with the general collection of applied science. Such a collection should be strictly technical in character ; otherwise there would be a risk of indefinite extension in this department.

6. The order in which we have described the collections in our third paragraph follows the arrangement adopted by the Science and Art Department in January 1888, and agrees with that suggested in paragraph 26 of Sir F. Bramwell's Report, where the "instruction given in the Normal School of Science" coupled with "the teaching of science generally throughout the United Kingdom," precedes "the acquisition of other objects in the interest of science or of the arts."

It is indeed evident that the collections in the Western Galleries, containing instruments and appliances indispensable for the teaching of science, are more closely connected with the work of the Normal School and the science classes in connection with the Department than the machinery, to which, however, some of the professors refer by way of illustration in their lectures ; and the machinery is more closely connected with the Normal School and science classes than are the ship models, which at present are not used at all for the school ; whilst the fish collection serves no direct educational purpose at all. We learn from the Treasury Letter of March 23 that the view as to the object of these collections expressed in paragraph 26 of Sir F. Bramwell's Report has in substance been adopted by Government, with the qualification that "the teaching of science generally" must be subject to "reasonable regulations."

Prof. Huxley, who, in one capacity or another, has had a very large share in the formation of these collections, maintains that the connection of the collections with the Normal School of Science is "accessory and accidental," the essential object of them being, firstly, "to facilitate practical instruction in science, particularly in the teaching in the science classes connected with the Department, by enabling teachers to acquaint themselves with the various apparatus, models, and specimens which are indispensable to proper scientific instruction, or which have been found especially useful in such instruction, and in original investigation," and, secondly, "the preservation of apparatus and models which possess historical interest as marking stages either in the progress of discovery or in that of the application of scientific principles to art and industry."

Without attempting to determine the relative value of such collections as regarded from different points of view, we would state that in our opinion their direct educational bearing does not afford an adequate test of their value and importance.

7. We proceed to consider *seriatim* the several sections of the collection, beginning with the "Appliances for Instruction and

Research" now in the Western Galleries. For this section, which now occupies a little over 22,000 square feet, the committee of professors, whose report was adopted by Sir F. Bramwell and his colleagues, estimated that 37,000 square feet were required, with an addition of 3,000 square feet in the next ten years, *i.e.* nearly double the area at present available. The space now provided is well filled but hardly overcrowded; the objects exhibited are, speaking generally, either of historical interest as illustrative of the development of scientific discovery, or representing the latest and most improved forms of scientific instruments and appliances. The collection is clearly of great use to the students in the Normal School, the professors of which draw upon it largely for illustrations of their lectures, or bring their classes into the galleries when that course is more convenient; and these remarks apply to the historical side of the collection almost as much as to its more immediately practical portions. It is of no less use to such of the teachers and students in science schools throughout the country (which receive grants from the Science and Art Department) as have opportunities of visiting it, whether singly or in organized classes. A special feature in the collection is the series of appliances for the teaching of science which it contains, sometimes systematically arranged ready for class use, sometimes shown as a group of similar objects made by different makers, with prices attached. We think that these samples (as they may be called) require very careful administrative watching in order to keep the selection exhibited up to the latest date and the best quality. For such specimens the Department has, especially in the early stages of the collections, been largely indebted to the assistance of private firms; for whom proper consideration must therefore be shown. These samples are doubtless of service to teachers, especially in the present comparatively undeveloped condition of elementary scientific teaching in this country; and the space occupied by them (mostly in wall cases) need not be large.

The collections now under consideration appear to have been on the whole carefully watched by a committee of professors in the Normal School, who, under the exigencies of a limited space, have eliminated from them almost all objects of an obsolete character. Little further weeding is possible in them as they now stand, except perhaps in the case of some of the samples described above. Turning to the other side of the question, the complaints of want of space do not appear to be very serious; and the future development of such collections can, we think, be met in part, but not altogether, by the elimination of objects which, appropriate and necessary to-day, will become obsolete in the inevitable progress of scientific knowledge and procedure. We say, "not altogether," because there ought to be retained a limited number of objects illustrating the historical development of the more important implements of scientific research; moreover, some natural increase must be contemplated arising from the introduction of new methods of scientific investigation. Wall space is all that is required for the exhibition of *diagrams*, which can often be usefully employed in lieu or in aid of actual objects or instruments.

The need for the exhibition of the appliances for elementary science classes may be expected to diminish as the organization of scientific education improves, in the same way as the universal extension of primary schools has removed the necessity for such an exhibition of school desks and fittings as formerly existed in this Museum.

Included in the 40,000 square feet provided for by Sir F. Bramwell's committee are 4000 square feet for "agriculture." At present only a very small collection exists in connection with this subject. Lectures are from time to time delivered at the Normal School, on the *principles* of agriculture, and the Department holds examinations in the same subject. But it is obvious that for the portions of this subject in which instruction can usefully be given in lecture-rooms, the illustrative collections required need occupy only a very moderate amount of space. Any complete collection of objects illustrative of the study of all branches of agriculture would require a space at South Kensington far larger than could be allotted to a mere branch of a Science Museum. The principal agricultural implements should be represented by models in the department of Machinery and Inventions; and provision seems to have been made for this purpose in the scheme for that department, to which we will subsequently refer.

The Western Galleries at present in use are fairly satisfactory as regards construction and lighting, and allow their nominal area and wall space to be utilized to the full extent of their capacity. They are, however, inconveniently situated as regards both the Normal School and the rest of the Museum, and we have little doubt that a building giving an equal accommodation could be provided at a cost less than the capitalized value of the rent (£2000 per annum) at present paid for them.

On the whole, we are of opinion that, having regard to the financial exigencies which must always be present to those intrusted with the expenditure of public funds, a moderate increase on the present space should, subject to one important proviso, suffice, for some time to come, for the needs of the Normal School and other requirements of this section.

The proviso to which we refer is, that there should be a well-organized system of management of the collection. We will revert hereafter to this point, which, in our judgment, affords the key to the whole question now before us.

8. Passing to the section devoted to Machinery and Inventions, we have to observe that this is of the nature of a technological museum rather than of a collection for the special benefit of the Normal School, or of the Science Classes connected with the Department. It is, however, to be observed that the Professor of Mechanics attaches great value to this collection for the purposes of his teaching; and that the objects used as illustrations by the Professor of Metallurgy (so far as he does not use diagrams) are practically included in this division of the Museum. Regarded from a broad point of view, the value and importance of this section must be admitted; and we approve of the policy which has been adopted by the Department in recent years, of developing it at the expense of less important collections. In pursuance of this policy the area of this section has increased from 11,000 to over 18,000 square feet, now occupied to nearly its full capacity. This is still very far short of the space of 45,000 increasing to 60,000 square feet adopted by Sir F. Bramwell's committee, and even of the more moderate demand of 40,000 square feet put forward by Mr. E. A. Cowper in his evidence before us, and based on carefully-detailed calculations. That gentleman has devoted a great amount of time and trouble to this collection, which bears the mark of his patriotic labours in the evident endeavour to utilize the available space to the best advantage. There are a few objects, but only a few, in this collection which could properly be eliminated; but we consider that care should be taken not to acquire or receive full-sized machines where models can be made to serve the same purposes, and also to avoid unnecessary multiplication of parts in either model or machine. For example, two or three rows of bobbins, &c., on a spinning frame show as completely the principles on which a machine is constructed as would a complete series, such as is to be found in actual use. Inferior or obsolete examples must be eliminated as better or more recent specimens are obtained, subject only to the retention of a few typical illustrations of historical development. Moreover, the development of the collection must inevitably be gradual, if properly carried out, as the right objects cannot be obtained off-hand, and the temptation to obtain or accept inferior examples should be avoided in every possible way. Even with these restrictions, we agree with Mr. Cowper that ultimate, if not immediate, provision of a maximum space of 40,000 square feet should be made for this branch of the Museum; and we believe that, under well-organized and efficient management such as we have already pronounced essential, this space, if provided by means of suitable buildings, ought to suffice to contain a technological collection worthy of a great manufacturing country. As a temporary measure, space might be found for the expansion of this section by the removal of the decorative objects which occupy the eastern end of the ground floor of the Southern Galleries.

9. *Naval Collections.*—Under this head are included complete models of vessels of various kinds, actual or proposed, forming an historical series, and mostly on loan; models illustrative of naval construction; and models of marine machinery, many of historic interest. In regard to this section of the Museum, we have had to consider the very debatable question of the suitability of South Kensington as a site for a marine collection. Though classes are examined by the Department in naval construction, no provision is at present made for teaching the subject in this locality. It is right, however, to say that "summer classes" in this subject are contemplated; and a class is intended to be held next autumn. It will be remembered that the School of Naval Architecture (in connection with which this collection was originally formed) has been removed to Greenwich, and has assumed a more prominently military character. It is not easy at first sight to regard the west end of London as

the most convenient centre for those interested in ship construction, especially considering the small amount of ship-building operations now conducted on the Thames. But it has been shown that there is a very strong sentiment among those interested in shipping in favour of the retention of the ship models in their present home, and the following are some of the practical reasons given in support of this view, by the Institute of Naval Architects and others :—

(1) The shipping companies and other owners of the large ornamental models have, it is said, declined to lend their property for permanent exhibition elsewhere than at South Kensington.

(2) The naval collections are closely connected with the Machinery and Inventions Section of the Museum.

(3) Being at South Kensington, the departmental system of circulation can, it is said, be applied to them.

This latter remark only applies in practice to a small portion of the collection, viz. the models, &c., illustrative of the details of ship construction. The large models of ships do not belong to the Department, and in any case are too large and too valuable to be sent round, under the plea of some slight educational utility, to local schools of elementary science ; though, under special circumstances, some of them have been lent by their owners to Exhibitions in the provinces, or even at Paris.

On the whole, we have arrived at the conclusion that it would be practically impossible to reconcile public opinion to the removal of this collection elsewhere, and that space must therefore be provided for it at South Kensington.

For this collection 10,500 square feet were demanded at once by the committee referred to in Sir F. Bramwell's Report, with an increase of 10,000 square feet. The space at present occupied is 15,374 square feet, or three-fourths of the maximum desired by the special committee. We consider that the present space should suffice, under proper administration, for an adequate exposition of the methods and results of the very important national industry of shipbuilding. In connection with this conclusion we would observe that, in our opinion—

(1) A certain number of the objects now exhibited could be eliminated "without injury to the value or representative character of the collections" ; and the fact that so much of the space is occupied by large ornamental models of ships, many of them on loan, would facilitate such elimination, when required for the introduction of new examples.

(2) Having regard to the fine historical and practical collection of war-ships which exists at Greenwich, and is readily accessible to the general public, the portion of the South Kensington collection which relates to ships of war should be reduced to a minimum. It now occupies twenty pages of the catalogue, in which fifty-three numbers are described.

(3) The additions to the collection, other than in substitution for objects eliminated, should mainly consist of diagrams or small models of *parts* of ships or machinery, suited for practical instruction in the art of ship-building. Such objects would be of use for circulation, and would not occupy any considerable amount of space.

10. *Fish Culture Collection.*—No mention of this collection is made in the departmental scheme of classification dated January 1888 ; and indeed it seems to bear little relation to the instruction given in the Normal School, to the teaching in science classes connected with the Department, or to the other sections of the Science Museum. Nor is South Kensington a situation naturally well adapted for fish-breeding operations. We beg to refer to the weighty opinion of Prof. Huxley as to the want of connection between this collection and its present surroundings, and the small educational or scientific value which it possesses in its present condition.

The greater part of this collection was bequeathed to the Department in 1880 by the late Mr. Frank Buckland, and a series of British fishes has, since that date, been presented to it by Dr. Day. This state of things would, however, in our opinion, hardly prevent the Department from transferring the collection to some other public institution. The Buckland Professorship, if the funds for its support are still available, might well be attached to the Marine Biological Laboratory at Plymouth, under regulations agreed to by the Science and Art Department. With the consent of the donors (when obtainable), some objects now forming part of this collection might find a place in the Natural History Museum ; and the remainder might be transferred to the Marine Biological Association, and the Scotch Fishery Board, provided that those bodies are able and willing to receive them. In any circumstances we are of opinion that there is no necessity for the collection being retained at South Kensington, and certainly no provision should be made for it in any building scheme there.

The large State barge and Venetian gondola now housed in the same galleries as the fish collection should also be removed.

11. *Circulation.*—With regard to that portion of the reference to us which relates to the system of circulation of objects in the provinces, we should explain that two different systems are comprised under that name. Under one of these, objects forming an integral part of the collections are lent by the Department, for a limited period, to local museums. This in the case of the science collections is only done on a small scale ; the space so vacated is insignificant and cannot be utilized for other purposes, and it has therefore no practical bearing on the housing of the collections. The other kind of circulation is confined to science schools in connection with the Department. It consists in the loan of a typical set of objects and apparatus suitable for the teaching of one branch or another of science, such as chemistry, geology, &c., with a view to improve the practical portion of local teaching. These circulating sets are never regularly exhibited at South Kensington, and therefore can only require a small amount of warehouse space for storage and arrangement. If the system of circulation grows, some additional warehouse space may be required, but no increase in the exhibition space would be involved.

12. The frequent mention in this Report of areas of exhibition space suffices to indicate how inevitably the question of housing the collections has been forced on our attention, notwithstanding that it does not explicitly form part of the terms of reference to us. In suggesting certain areas as, in our opinion, sufficient to meet the requirements of the case, we have assumed that the exhibition buildings should be well arranged, well lighted, and of a durable character. These requisites, however, are not fulfilled in the case of the Southern Galleries, the upper floor of which is, we are informed and believe, incapable of supporting considerable weights, so that collections of machinery cannot be placed in that portion of the building. It may also be observed that these galleries appear not to be well secured against fire. The rent of £1500 per annum is paid for the central block of this building, for the capitalized value of which sum a larger and more convenient building could apparently be erected. The present state of dispersion of the Museum involves extra expense in connection with the entrances, attendants, and police, and also increases the difficulty of an efficient superintendence by the superior officers in charge of the collections. We feel bound to call attention to these facts, which have been forcibly impressed on us by our observations on the spot as well as by the evidence we have received.

13. We have already adverted to another matter which, though outside the literal terms of reference to us, is in our judgment of the very greatest importance in regard to the substance of the questions under consideration. We allude to the organization for the custody and management of the collections. At present this duty rests, under the Secretary, with the staff of the Director of the Museum, whose functions cover both the Art and the Science divisions, which differ widely from one another. Attached, however, to each section of the Museum is a separate consultative committee ; which, for the collections of scientific instruments and appliances, consists of the professors of the Normal School ; while in the case of the other sections, the committees consist of gentlemen external to the Department. These committees can only recommend, not decide ; and even when their recommendations are adopted, it does not follow that they can see that they are carried out. To committees of this kind the task of refusing unsuitable loans is also peculiarly difficult and irksome ; and there is also some danger of different committees causing overlapping between different portions of the collections, although we have no reason to think that this has as yet happened. On the other hand, there seems to be no system of regular meetings of the committees at prescribed intervals (oftener than once a year), and regard being had to the composition of the committees, it is not to be expected that many members of them should be able to devote much time to this work, certainly not to the detailed and continuous supervision which collections require. It must not be supposed that nothing has been gained from the existence of these committees ; on the contrary, Mr. Cowper's work on the machine collections is an instance of the excellent service which individual members have rendered. But we consider the system defective in principle,

apart from the personal qualities of those working under it; and having formed a very decided opinion to this effect, we feel it our duty to call attention to the subject, in the interests of economy as well as of efficiency. The responsibility for the formation and supervision of these collections should certainly be of a more definite kind.

14. Suggestions have been made that these collections might encroach on the field occupied by other scientific museums. With regard to this point we would call attention to the evidence of Prof. Judd as showing that a practical distinction can readily be drawn even at a point where two Museums closely approach one another in character.

15. In conclusion, we may summarize the results of our inquiries by expressing the opinion that little, if any, space can be gained by weeding the existing collections, and that, subject to the reservations we have made as to effective organization and administration, and as to the character of the buildings to be assigned to the collections, an exhibition space of about 90,000 square feet should be provided without delay, and would suffice for the requirements of a creditable Science Museum, with adequate space for all the departments for which it appears at present necessary to provide. This space includes provision for a scientific structural collection on the lines indicated in paragraph 5 of this Report, but does not include any provision for offices, warehouses, workshops, or other accessories to such a Museum.

JOHN EVANS.
FRANCIS HERVEY.
RAYLEIGH.
B. SAMUELSON.
DOUGLAS GALTON.
HENRY E. ROSCOE.

STEPHEN E. SPRING RICE, Secretary.
July 23, 1889.

AN ITALIAN'S VIEW OF ENGLISH AGRICULTURAL EDUCATION.[1]

IN this *brochure*, M. Italo Giglioli, Professor of Agricultural Chemistry at Portici, has collected together a large amount of information upon agricultural education and agricultural research as carried out in the United Kingdom. A similar work upon the teaching of agriculture throughout Europe, by the same author, appeared last year. It is, however, noticeable that the volume on English agricultural education is three times the bulk of the earlier effort. M. Giglioli, as a foreigner, has considered our methods worthy of a much more detailed Report than those of the Continent. This can only be regarded as a tribute to the excellence of English agriculture. We have heard a great deal of late upon the small amount of interest taken in agricultural education in England compared with Continental countries. An Italian Professor finds material for a portly volume on our systems of agricultural education and research, while he is able to compress his information upon the German, French, and Hungarian systems into a pamphlet of comparative thinness.

As a matter of fact, the Continental nations have been, at least in the past, ahead of us in these matters. The value of what is done in England rests rather upon the quality of our agriculture than upon our efforts to systematically teach it. Continental Professors of Agriculture find it as essential to visit England and to study English agriculture, as would an American Professor of History to visit Europe, or a Biblical student to visit Egypt and Palestine. The most noted breeds of cattle, sheep, and pigs, the best types of implements and machinery, the best artificial manures, the best systems of farming, have originated in England and Scotland, and hence the attention which is paid to agricultural research as prosecuted in Britain. So far, however, as the study of Agriculture is concerned, or painstaking and wide-spread investigation goes, the Continental nations are before us. It is not by any means certain that with these advantages they will excel us in the actual practice of agriculture. As a nation we are more adapted for doing than for study, and our progress is generally the result of pressure under competition, and the spontaneous adoption of the best practices, as they are published in the press. Our improvements are less likely to emanate from technical schools than from the promulgation of new ideas, new processes, new material, new appliances, adopted by leading agriculturists, exhibited and reported upon.

M. Giglioli, like all Continental visitors to England, wonders with great admiration at the spontaneous character of our efforts. Here, we succeed without Government help. There, both teaching and research often languish, although supported by huge grants, and are always discontentedly asking for more. "Il carattere più saliente che le distingue da tutte le altre scuole agrarie di Europa, è quello della loro completa autonomia, anche finanziaria. Esse non ricevono sussidio alcuno nè dal Governo, nè da provincie, nè da associazioni agrarie: vivono completamente sopro quello che quadagnano. Il contrasto tra le scuole inglesi e le continentali appare nel seguente quadro." The author then recounts, in tabular form, the cost to the student, and the incomparably greater cost to the State, of agricultural education in Germany, France, and Italy; and, after showing that each student costs his State from 700 to 2500 lire, in addition to his own costs, he triumphantly writes "*niente*" in the column showing the cost to the State opposite the chief English agricultural schools.

The author's introductory remarks having been concluded, the principal Societies engaged in agricultural education in these countries are next passed in review, and their methods, examinations, prizes, diplomas, are described. Such matter will no doubt be more interesting to Italian agriculturists than to ourselves. The number of these means of instruction is probably greater than many Englishmen are aware of, and, as a point of considerable interest at the present time, we take the following list from M. Giglioli's book:—

The Royal Agricultural Society of England (an examining body).
The Rothamsted Experimental Station (for research only).
The Royal Agricultural College, Cirencester (instructional and examining body).
The College of Agriculture, Downton (instructional and examining body).
The Colonial College, Hollesley Bay (instructional and examining).
The Department of Science and Art, South Kensington (instructional and examining).
The Darlington Chamber of Agriculture (Lecturer employed).
The Normal School of Science, South Kensington (Agricultural Professorship).
The University of Oxford (Sibthorpian Professorship).
King's College, London (Agricultural Lectureship).
City of London College (Agricultural Lectureship).
The Worleston Dairy School, Cheshire.
The Sudbury Dairy School.
The Weald of Kent College of Agriculture.
The School of Agriculture, Aspatria, Cumberland.
The Agricultural School at Alvecote, Tamworth.
The agricultural instruction given at various County Schools.
The facilities for agricultural instruction in rural Elementary Schools.
The Forestry Department at Cooper's Hill.
The Surveyors' Institution, 12 Great George Street, Westminster (examining body).
The Royal Veterinary College, Camden Town.
The Brown Institute.
The Highland and Agricultural Society (examining body).
The Agricultural Department of the University of Edinburgh.
The Agricultural Department of the College of Science and Technology, Edinburgh.
Course of Agriculture at Glasgow Technical College.
The Agricultural Department in Aberdeen University.
The Royal Veterinary College, Edinburgh.
The New Veterinary College, Edinburgh.
The Veterinary College, Glasgow.
The Agricultural School at Templemoyle, Ireland.
The Royal Albert Institution, Glasnevin, Dublin.
The Dairy School for Females, Glasnevin.
The Munster Dairy School, near Cork.
Canon Bagot's Creameries, Ireland.
The Governmental agricultural instruction in Elementary Schools, Ireland.

The above Societies, Colleges, and Schools engaged in the work of agricultural education are all carefully described. The list might have been made longer, as M. Giglioli does not seem

[1] "Educazione agraria Britannica," relazione di Italo Giglioli. (*Annali di Agricoltura*, 1888.)

to be aware of various dairy and other agricultural schools which have been recently founded, or are now being promoted. Among these may be especially mentioned the Travelling Dairy School of the Bath and West of England Society.

JOHN WRIGHTSON.

"INFERNITO."

SOME strange natural phenomena are described in a recent report from the United States Consul at Maracaibo in Venezuela. That part of the département of Colon situated between the Rivers Santa Ana and Zulia and the Sierra of the Colombian frontier is very rich in asphalt and petroleum. The information we have regarding this extensive and interesting region, which is an uninhabited forest, is derived chiefly from the reports of the searchers after balsam copaiba, which abounds; but the following data were taken from the personal observations of an American gentleman who made a special exploration. Near the Rio de Oro, at the foot of the Sierra, there is a very curious phenomenon consisting of a horizontal cave which constantly ejects thick bitumen in the form of large globules. These globules explode at the mouth of the cave with a noise loud enough to be heard at a considerable distance; and the bitumen, forming a slow current, falls finally into a large deposit of the same substance, near the river bank. The territory bounded by the Rivers Zulia and Catatumbo and the Cordillera is rich in deposits and flows of asphalt and petroleum, especially towards the south, where the latter is very abundant. At a distance of a little more than 7 kilometres from the confluence of the Tara and the Sardinete, there is a sand mound of from 25 to 30 feet in height, with an area of about 8000 square feet. On its surface are a multitude of cylindrical holes of different sizes, which eject with violence streams of petroleum and hot water, causing a noise equal to that produced by two or three steamers blowing off simultaneously. For a long distance from the site of this phenomenon the ground is covered or impregnated with petroleum. The few explorers for copaiba who have visited this place call it the "Infernito" (little hell). Among other things, it is stated that from one only of these streams of petroleum was filled in one minute a receptacle of the capacity of four gallons. This represents 240 gallons in an hour, or 5760 gallons in 24 hours; and even if this calculation be somewhat exaggerated, the fact remains that such a considerable number of petroleum jets in constant active operation must produce daily an enormous quantity. This petroleum is of excellent quality, with a density of 83°, which is a sufficient grade for foreign markets. Considering the immense amount of inflammable gases which must be given out by the flows and deposits of petroleum as described above, it may be easily believed that this has a direct bearing upon the phenomenon known since the conquest as the Faro of Maracaibo. This, consisting of constant lightning without explosion, may be observed towards the south from the bar at the entrance to the lake, and Coddazzi in his geography explains it as being caused by the vapours arising from the hot water swamp situated about one league to the east of the mouth of the Escalante, at the southern extremity of the lake. Near the mountains, and not far from the River Torondoy, there are various flows of a substance which seems to be distinct from either asphalt or petroleum. It is a liquid of a black colour, with little density, and strongly impregnated with carbonic acid, and is almost identical with a substance met with in the United States among the great anthracite fields.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 2.—"On the Spectrum, Visible and Photographic, of the Great Nebula in Orion." By William Huggins, D.C.L., LL.D., F.R.S., and Mrs. Huggins.[1]

It might be suggested that the want of coincidence observed between the nebular line and the magnesium band, amounting to λ 0001·9 nearly, might be due to a motion of translation of the nebula towards the earth. The motion required to produce this shift of position is about sixty-seven miles in a second. [The earth's motion at the time of comparison with magnesium band may be taken at nearly seventeen miles in a second of recession from the nebula. This motion would bring the nebular line nearer the red, and diminish the apparent interval between that line and the termination of the band. If the nebula has a motion of approach, the earth's motion would bring the line back again, to an extent corresponding to about seventeen miles in a second, towards its true plane.—*May* 18.]

I showed in my paper on this subject in 1874 (Roy. Soc. Proc., vol. xxii. p. 253), that, in the case of the Orion nebula and six other gaseous nebulæ—namely, 4234, 4373, 4390, 4447, 4510, 4964, of Sir J. Herschel's "General Catalogue of Nebulæ"—"in no instance was any change of relative position of the nebular line and the lead line detected." We should have to resort, therefore, to the overwhelmingly improbable supposition that all seven nebulæ were approaching the earth with velocities such that, having respect to the earth's motion at the different times of observation, they all gave a sensible shift corresponding to 67 ± 15 miles in a second.[1] There is little doubt in my mind, therefore, from these comparisons, which, considering the strong evidence we possessed before of the relative positions of the nebular line and of the magnesium line, are, strictly speaking, supplementary and confirmatory evidence only, that this line of the gaseous nebulæ is not produced by "the remnant of the magnesium fluting."

In the diagram on p. 134 (Roy. Soc. Proc., vol. xliii.), Mr. Lockyer represents this nebular line followed by fine lines, which give it the appearance of a fluting similar to that of the magnesium band placed above. I am unable to find in the paper any authority for this representation of the line. In another place (Programme Royal Society *Soirée*, May 9, 1888, p. 12) Mr. Lockyer says: "On one occasion, at Greenwich, it was recorded as a fluting in the spectrum of the nebula in Orion." Mr. Maunder's words are ("Greenwich Spectroscopic Results," 1884, p. 5): "None of the lines (with two-prism train) are very sharp. λ 5005 showed a faint fringe mainly on the side nearer the blue."

Mr. Maunder has recently sent a note to the Royal Astronomical Society, in which he explains that the observation was made with a second half-prism added to the half-prism spectroscope. He says:—"The three principal lines of the nebular spectrum were seen as very narrow bright lines, but none of them were perfectly sharp, each showed a slight raggedness at both edges; but in the case of the line near λ 5005 it was clear that this fringe, or raggedness, was more developed towards the blue than towards the red. In the case of the other two lines, they were not bright enough for it to be possible to ascertain whether the fringes were symmetrical or not. But λ 5005 was clearly a single line. There was no trace of any bright line, or series of bright lines, close to it on either side; no trace of a fluting, properly so called. The entire line, fringes and all, was only a fraction of a tenth-metre in total breadth" (*Monthly Notices R.A.S.*, vol. xlix., 1889, p. 308). [It should be noticed that, with the instrumental conditions under which Mr. Maunder observed, the second and third lines were not sharp, but also showed fringes.—*May* 18.]

My own observations of this line, since my discovery of it in 1864, with different spectroscopes up to a dispersion equal to eight prisms of 60°, show the line to become narrow as the slit is made narrow, and to be sharply and perfectly defined at both edges.

[1] Continued from p. 407.

[1] [The following observations of Orion for motion in the line of sight have been made at Greenwich:—

1884. February 15—About thirty-one miles approach. Note, *measures purely tentative.*
February 18—About fifty-one miles approach. Note, *the measures are not trustworthy.*
March 10.—*Direct comparison.* With neither one nor two prisms, after very careful direct comparison, could any displacement be detected; the coincidence of the two spectra was evidently very close.
March 12.—*Direct comparison.* . . . Direct comparison with one prism-train showed coincidence as complete as could be detected, considering the faintness of the two spectra. . . . No part of the nebula showed any marked displacement, but at a point a little preceding the Trapezium the pointer did not seem perfectly central on the line, but a little (perhaps one-tenth, certainly not more) towards the red.

1887. October 25.—Six measures, three of which show approach, and the other three recession. Note, lines in nebula faint, and bisections very rough.

In a letter dated May 17. Mr. Maunder permits me to state that the measures and estimations made in 1884 and 1887 are of no weight, but that he considers the *comparisons* in March 1884 to be as satisfactory as possible with so faint an object, and to show that the nebula has very little, if any, sensible motion in the line of sight.—*May* 18.]

As some importance attaches to the precise character of this line, I wrote to Prof. H. C. Vogel for permission to quote the result of his experience, which has been nearly as long as my own, of the character of this line. He says in his reply, dated March 20, 1889: "Beeile ich mich Ihnen mitzutheilen, dass meine langjährigen Beobachtungen über die Spectra der Gas-Nebel *vollkommen* mit den Ihrigen darin übereinstimmen, dass die Nebellinie λ 5004 schmal, scharf und nicht verwachsen ist. Auch D'Arrest hat in seiner Untersuchung über die Nebel-Spectra (Kopenhagen, 1872) nicht erwähnt dass die hellste Nebellinie unscharf sei."

Dr. Copeland permits me to quote the following sentences of a letter dated March 19, 1889:—"Respecting the appearance of the line λ 5004 in the spectrum of the Orion nebula, I may say that I have always drawn and seen it quite sharp and well defined on both edges. About nine years ago I made a special effort to divide it, if possible, with a large spectroscope in which the viewing telescope was 3 inches in aperture. The lines were then seen as sketched." (The diagram shows the nebular lines with sharply ruled lines for edges.) "They were drawn by holding the note-book 10 inches from the left eye, in such a position that the image seen in the instrument with the right eye was apparently projected on the paper. If I had noticed any peculiarity about λ 5004, it would certainly have been noted."[1]

In an early observation of the dumb-bell nebula Prof. Vogel, indeed ("Beobachtungen zu Bothkamp," p. 59, 1872), describes this line as less defined towards the violet side. In a letter (April 3, 1889) Prof. Vogel says this appearance of the line was probably due to a slit not sufficiently narrow. He says that he re-examined this line in his observations with the great Vienna refractor, and that it did not then appear otherwise than defined and narrow.

The other line in the spectrum of the nebulæ upon which Mr. Lockyer mainly relies for the presence of magnesium is the line shown in my photographic spectrum of 1882 (Roy. Soc. Proc., vol. xxxiii. p. 425), and to which I assigned the wave-length of about 3730. Mr. Lockyer says of this line (Roy. Soc. Proc., vol. xliii. 1887, p. 122): "In the bunsen as ordinarily employed the fluting at 500 far eclipses the other parts of the spectrum in brilliancy, and at this temperature, as already observed by Messrs. Liveing and Dewar, the ultra-violet line visible is that at 373." Passing by a minor point, which Liveing and Dewar have already pointed out (Roy. Soc. Proc., vol. xliv., 1888, p. 244), namely, that their observation was made at the higher temperature of burning magnesium, this statement is insufficiently complete, for what occurs at this part of the spectrum, and is characteristic of the magnesium-flame spectrum, is a triplet, of which the line given by Liveing and Dewar at about 3730 is the least refrangible member only.

I have given a representation of this triplet at the wave-lengths given by Liveing and Dewar, namely λ 3730, 3724, and 3720. In the photograph of 1888, in which the strong line can be seen distinct from the lines near it, the line is found to be very near the middle line of the triplet. I have therefore assigned to this line the position of about λ 3724. This line appears pretty strong, and therefore if it were really one of the lines of the triplet, the other two members of the triplet should have appeared on the plate. On one side of the star-spectra this line is a little broader than on the other side, but as a similar appearance is presented by G, and the stronger of the lines of the group, it may arise from some optical or photographic cause. The line at 3724 impresses me strongly as a single line, and there is certainly no trace of the first line of the triplet at 3730. The line appears to me stronger where it is upon the star-spectra.

As therefore there is little doubt that the "remnant of the fluting at 500, which far eclipses the other parts of the spectrum in brilliancy," is not coincident with the brightest nebular line, and the next most characteristic group of this spectrum, the triplet at 3722, 3724, and 3730, according to Liveing and Dewar, does not appear to be present in the photographs, we may conclude that the remarkable spectrum of the gaseous nebulæ has not been produced by burning magnesium.[1]

I should mention that Mr. Lockyer attributes one other line occasionally seen in the gaseous nebulæ to the flame spectrum of magnesium—namely, a very faint line at about λ 4700. Now, according to my experience, it is only in the spark and arc that a line of magnesium appears at this place, a condition of the spectrum when the lines at *b* are very conspicuous, and the band at λ 5006·5 is usually absent. When, however, the spark is taken in magnesium chloride, the band is present under some conditions, but the triplet at *b* is always bright. I therefore consulted Prof. Liveing, who says:—"I have never seen the line at λ 4703 in the spectrum of the magnesium flame. As it is a conspicuous line in the arc and spark, we looked for it in the flame, but did not find it."

With reference to the second nebular line at λ 4957, Mr. Lockyer says (Roy. Soc. Proc., vol. xliii. p. 133): "The lines at 500 and 495 have been seen in the glow of the Dhurmsala meteorite when heated, but the origin of 495 has not yet been determined." And further (at p. 135): "I should add that the line at 495 makes its appearance much more rarely than the one at 500 in meteorite glows." In the diagram on the same page this line is represented as coincident with the nebular line.

The circumstance of a line appearing at 495 can scarcely be regarded, considering the very great number of spectral lines, as amounting to a presumption that the material to which it is due in the meteorite is the same as that present in the nebulæ which gives the line at 4957. If it should be shown that the unknown substance in the meteorite gives rise to a line at the position of the nebular line—namely, λ 4957—in that case the observation would have sufficient importance to make it desirable to compare the spectrum of the meteorite directly with that of the nebula.

Lines Observed and Photographed in the Spectrum of the Nebula.

Line measured by Dr. Copeland, probably D_3 ...		λ 5874·0
Brightest line...		5004·6 to 5004·8
Second line ...		4957·0
Third line, Hβ ...		4860·7
Fourth line, Hγ ...		4340·1
Line measured by Dr. Copeland ...		4476·0
Strong line in photographs 1882 and 1888, about ...		3724·0
Line in photographs 1888, about ...		3709·0
,, ,, ,, ...		3699·0
Photograph 1889. 1st pair	about...	3752·0
	,, ...	3741·0
,, 2nd pair	,, ...	3285·0
	,, ...	3275·0
Line at	,, ...	3060·0
,, 3rd pair	,, ...	3053·0
	,, ...	3047·0
Photograph 1888 ... Line across star spectra, 1st group ...	,, ...	4116·0
	,, ...	4123·0
	,, ...	4130·0
	,, ...	4142·0
	,, ...	4154·0
	,, ...	4167·0
2nd group ...	approximate	3998·0
	,,	3988·0
	,,	3975·0
	,,	3959·0
3rd group ...	,,	3890·0
	,,	3887·0
	,,	3878·0
	,,	3870·0
	,,	3859·0
	,,	3854·0
	,,	3848·0
	,,	3842·0
	,,	3832·0
	,,	3825·0

[1] Mr. Taylor, late of the South Kensington Laboratories, observing at Sir Henry Thompson's observatory in November 1888, says:—"The 5001 line is by far the brightest in the spectrum. It is never seen sharp, but with the narrowest slit always has a fluffy appearance, this being much more marked on the blue than on the red edge. This line was most carefully examined for evidence of structure, but was always found to be single, and no decided evidence of fluting structure could be made out. It may be that greater dispersion may show structure, but with the dispersion used here no structure could be seen."—*Monthly Notices R.A.S.*, vol. xlix. p. 125.

[1] On the narrower basis of the magnesium spectrum only, Profs. Liveing and Dewar point out that "the appearance of a line in the position of the first band without any trace of the second band, which is nearly as bright as the first, and without any trace of the *b* group, is quite sufficient to create a suspicion of mistaken identity when Mr. Lockyer ascribes the sharp green line in the spectrum of nebulæ to this band of magnesia. This suspicion will be strengthened when it is noticed that the line in question is usually in nebulæ associated with the F line of hydrogen, if it be borne in mind

Chemical Significance of the Lines.

Until I can obtain more photographs taken on different parts of the nebula, I wish to be understood to speak on this point with much hesitation, and provisionally only. We know certainly that two of the lines are produced by hydrogen. The fineness of these lines points to a high temperature and condition of great tenuity of the hydrogen from which the light was emitted. This condition of the hydrogen may give us a clue as to the probable interpretation of the other lines. These may come from substances of very low vapour-density, and under molecular conditions which are consistent with a high temperature. It is in accordance with this view that the recent measures of Dr. Copeland, since confirmed by Mr. Taylor (*loc. cit.*), show with great probability that the line known as D_3, which has been supposed to indicate some substance of low vapour-density, which shows itself only at the hottest region of the sun, is present in the nebular spectrum. The great simplicity of the three pairs of lines seen in the photograph of 1889 suggests a substance of a similar chemical nature.

If hydrogen can exist at half its usual vapour-density, with a molecule of one atom only, we might possibly expect to find it in some of these bodies, but at present we do not know what its spectrum would be in such a condition. It may be possibly that it is in molecular states of our elements other than those we are acquainted with that we may have to look for an interpretation of some of the lines of these bodies.

[With respect to the groups of lines which cross the star spectra, any statements must also be provisional only.

These lines are distinct and fairly strong in the star spectra, and do extend, some farther than others, into the adjoining nebular matter. Whether they are peculiar to these particular stars and the matter close about them, or whether they will be found everywhere in the nebula, or in certain parts of greater condensation only, can be known only from future photographs.

The first group shows some general agreements with a strong iron group, but there are also formidable discrepancies.

The position of the third group suggested the well-known cyanogen group, especially as this group, beginning at λ 3883, is the first to appear under the chemical conditions which might have been conceived to exist under circumstances of condensation (see Liveing and Dewar, Roy. Soc. Proc., vol. xxxiv., 1883, p. 128). Under these conditions this group appears alone in a photograph, without the less refrangible group, as was probably the case in the photograph I took of Comet II., 1881. I therefore took a photograph of an oxy-coal-gas flame, the coal-gas having passed through ammonia, and a magnesium-flame spectrum on the same plate for comparison.

On comparing this photograph with that of the nebula it was seen by eye, and afterwards confirmed by measurement, that the nebula group begins sooner by one strong line than the cyanogen group, and presents besides in the relative strength and grouping of the lines a distinctly different character. The evidence appears to me to be against attributing these lines to cyanogen.

I took great pains to ascertain if the group of lines which accompanies the triplet of the magnesium-flame spectrum could be made to agree with the much longer group of lines in the nebula at this part of the spectrum. Again, as in the case of the cyanogen group, the whole aspect of the grouping of lines is quite different. The groups begin and end differently, and the relative strength of different parts of the group is not the same. The great increase of strength which is seen in the middle of the magnesium group is not present at the corresponding part of the nebula group. I do not think therefore there should be much weight given to the near positions of several individual lines of the two groups, which in the case of so close a grouping might well be accidental, especially as the wave-lengths can be but approximate only. (The strongest lines of the magnesium-flame group are those forming the triplet which appears also in the spark and the arc. A nebular line is near the middle line of the triplet, but there are no lines corresponding to the other lines of the triplet. The other lines of the flame group are too faint to be expected to appear, unless the triplet at 3720—3730 were strong upon the plate.—*May* 18.)

The three pairs of lines in the photograph of 1889, which are doubtless rhythmically connected, appear to me to possess great interest, especially if it should come to be found from future photographs that these groups are characteristic of the most tenuous part of the nebula. At present, I am not able to make any suggestion as to their chemical origin, but the suggestion presents itself that we may have to do with some molecule of very low vapour density.

The pair of lines on the more refrangible side of the line at λ 3724, may possibly be connected with the state of the nebula as it exists in the neighbourhood of the stars.—*April* 26.]

that the spark of magnesium in hydrogen does not give the bands, and that the oxyhydrogen flame hardly produces them from magnesia when the hydrogen is in excess" (Roy. Soc. Proc., vol. xliv. p. 245). Mr. Taylor records a brightening of the continuous spectrum of the nebula at λ 5200, which he suggests may be magnesium. But this position is twenty-five units from that of the middle of the magnesium triplet at *b* (*Monthly Notices R.A.S.*, vol. xlix p 125).

General Conclusions.

It seems to me premature until we can learn more of the significance of the new groups of lines, and especially of their connection with the nebular matter generally, or with certain condensed parts only, to express more than provisional suggestions as to the nature of these nebulæ. It may be that they represent an early stage in the evolutionary changes of the heavenly bodies.

As some physical importance, in the relation of these nebulæ to each other, has been given to my inability, in consequence of insufficient optical means in my original observations in 1864, to see all three of the bright lines in some faint nebulæ, I may mention that in the case of one object, the Ring Nebula in Lyra, in which at that time the light appeared monochromatic, as only the brightest line could be certainly seen, as soon as larger means were placed at my disposal by the loan of the Royal Society telescope in 1870, I had no difficulty in seeing all three lines on any night of sufficient clearness. There is little doubt that the same cause prevented me from seeing more than the brightest line in Nebula 4572 of Herschel's "General Catalogue." Vogel saw two lines ("Beobachtungen zu Bothkamp," 1872, p. 59).

These bodies may stand at or near the beginning of the evolutionary cycle, so far as we can know it. They consist probably of gas at a high temperature and very tenuous, where chemical dissociation exists, and the constituents of the mass, doubtless, are arranged in the order of vapour-density. As to the conditions which may have been anterior to this state of things, the spectroscope is silent. We are free, so far as the spectroscope can inform us, to adopt the hypothesis which other considerations may make most probable. On Dr. Croll's form of the impact theory of stellar evolution, which begins by assuming the existence of stellar masses in motion, and considers all subsequent evolutional stages to be due to the energy of this motion converted into heat by the collision of two such bodies, these nebulæ would represent the second stage in which these existing solid bodies had been converted into a gas of a very high temperature. They would take the same place, if we assume with Sir William Thomson (Roy. Instit. Proc., vol. xii. p. 15) the coming together of two or more cool solid masses by the velocity due to their mutual gravitation alone.

I pointed out in 1864 (Phil. Trans., 1864) that the gaseous nature of these bodies would afford an explanation of the appearance of flat disks without condensation which many of them present. The light emitted by the portions of the gas further from us would be in part or wholly absorbed by the gas through which it would have to pass, in this way giving to us the appearance of a luminous surface only.

In some of these bodies there is also a very faint continuous spectrum, which if we had more light might be found to consist, in great part at least, of closely adjacent bright lines. Such is probably the nature, in part, of the apparently continuous spectrum of the nebula with which this paper deals chiefly, the Great Nebula in Orion.

In other gaseous nebulæ strong condensations are seen, and a stronger "continuous" spectrum. When we come to nebulæ of which the nebula in Andromeda may be taken as representative, the strong bright-line spectrum is absent, and we have what for convenience I called, in my original observations of these bodies, a "continuous" spectrum, though I was careful to point out that it was probably "crossed by bright or dark lines."

Out of about sixty nebulæ and close clusters observed by me up to 1866, I found a proportion of about one-third—namely, nineteen—to present the spectrum of bright lines (Phil. Trans., 1866, p. 383).

The stage of evolution which the nebula in Andromeda represents is no longer a matter of hypothesis. The splendid photograph recently taken by Mr. Roberts of this nebula shows a planetary system at a somewhat advanced stage of evolution; already several planets have been thrown off, and the central gaseous mass has condensed to a moderate size as compared with the dimensions it must have possessed before any planets had been formed.

SYDNEY.

Royal Society of New South Wales, July 3.—Prof. Liversidge, F.R.S., President in the chair.—The Chairman announced that Mr. C. S. Wilkinson, the Government Geologist, had kindly consented to deliver (gratuitously) a course of (three) lectures in connection with the Clarke Memorial, commencing in October or November next.—The following papers were read:—Notes on the high tide of June 15–17, 1889, by John Tebbutt; and on the marine and fresh-water Invertebrates of Port Jackson and the neighbourhood, by Thomas Whitelegge. At the conclusion of the latter paper the President presented the Society's bronze medal, which, together with a money prize of £25, had been awarded to Mr. Whitelegge for his paper.—Prof. Anderson Stuart showed a modification of the "kymoscope" which he exhibited at the Society's last monthly meeting. This form demonstrated the phenomena of interference in wave motion—one series of tubes had one wave, a parallel series had the other, and both opened into a common series in which the interference was made visible. The two waves came from pumps which could be so arranged as to vary the amplitude of the waves and to change the position of the straight lines produced when the waves met or "interfered."

PARIS.

Academy of Sciences, August 19.—M. des Cloizeaux, President, in the chair.—Remarks on the conditions under which the fixation of nitrogen is effected in argillaceous soils, by M. Berthelot. Here is described a fresh series of experiments on the fixation of nitrogen in the ground with the co-operation of living organisms, microbes, and more highly organized plants. Replying to a recent communication of M. Schlœsing on the negative results of his studies, M. Berthelot accepts these conclusions, and even claims priority for them, adding, however, that they were given by him as defining the negative conditions of the phenomenon—that is, the conditions under which the fixation of nitrogen does not take place. In a second paper M. Berthelot describes some further researches on the fixation of nitrogen by vegetable humus under the influence of electricity.—Note on the glacial epoch, by M. H. Faye. It is argued that glaciation does not depend on any direct cause, such as a passing obscuration of the sun at the beginning of the Quaternary epoch, but is due to a far more remote cause—that is to say, the appearance of the seasons and of the poles of low temperature at a time when the sun had acquired its definite form and dimensions. A repetition of the great changes that took place during Tertiary times has been prevented by the continually increasing thickness of the terrestrial crust and by the slower rate of progress of the cooling process.—Observations on the sardine frequenting the Mediterranean waters, by M. A. F. Marion. The results are here communicated of the researches made by the author during the fishing season 1888–1889, for the purpose of verifying and completing his previous observations on the migrations and life-history of the sardine periodically visiting the shores of the Mediterranean.—On the total eclipse of August 19, 1887, by M. N. Egoroff. This is a summary of the Russian report on the observations of the eclipse of 1887 made at the seven stations of the Russian Physico-Chemical Society in accordance with the programme prepared by the Special Commission.—Electric figures produced by lightning, by M. Ch. V. Zenger. The curious effects are described of an electric discharge which struck a silvered mirror during a terrific thunderstorm near Prague, on June 9, 1889. The mirror shows over ten points at which the electric fluid penetrated through its gilded frame, volatilizing and transferring the gold to the anterior face of the glass, while on the opposite side the volatilization of the silver coating produced the most beautiful electric figures. These figures show that there occurred repeated and successive discharges, as also indicated by recent photographs of flashes taken with the oscillating camera obscura.—Observation of the occultation of Jupiter and its satellites by the moon, taken at the Observatory of Nice, by M. Perrotin. The hours of the various phases of the occultation that took place on August 7, 1889, are tabulated at mean time at Nice. The satellites are shown to have disappeared, not instantaneously, but gradually during several tenths of a second.—Observations of the new planet discovered at the Observatory of Nice on August 3, 1889, by M. Charlois. The observations are for the period August 3–6, when the planet had the brightness of a star of magnitude 13·5 to 14.—On a new mode of teaching music, based on the periodicity of the octave, by M. Ricard. The author aims at a radical reform in the teaching of music, and expounds his system in a series of fundamental propositions, such as: musical effect is quite different from acoustic effect; there can be no physical gamut, a major and a minor, but one only, that of the white notes of the piano, called the major, and so on.—On contraction in solutions, by M. Charpy. The object of these researches is to determine how the contraction produced in the process of solution varies with its concentration.—On the phosphotungstic acids, by M. E. Péchard. The methods hitherto employed for the preparation of these acids have all been indirect. But the study of metatungstic acid has suggested to M. Péchard the possibility of realizing the direct union of this acid with phosphoric acid. The general method of preparation consists in evaporating, under suitable conditions, a mixture of both acids in determined proportions.—On the passivity of cobalt, by M. Ernest Saint-Edme. It is shown that certain treatises on chemistry are wrong in stating that cobalt in the presence of concentrated nitric acid becomes *passive* like iron and nickel.—On the heat of combustion of some organic compounds (continued), by M. S. Ossipoff. The author's series of determinations is here concluded with teraconic acid, malic anhydride, methyl fumarate, and maleate of methyl.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Leçons Synthétiques de Mécanique Générale: M. J. Boussinesq (Paris, Gauthier-Villars).—Traité d'Optique, tome premier, M. E. Mascart (Paris, Gauthier-Villars).—Index Generum Avium; a List of the Genera and Subgenera of Birds: F. H. Waterhouse (Porter).—The Alternate Current Transformer in Theory and Practice; vol. i. The Induction of Electric Currents: J. A. Fleming (*Electrician* Office).—Album von Celébes-Typen: Dr. A. B. Meyer (Dresden).—Lung-Ch'Uan-Yao oder Altes Seladon-Porzellan: Dr. A. B. Meyer (Berlin, Friedländer).—Le Développement de l'Image Latente: A. de la Baume Pluvinel (Paris, Gauthier-Villars).—Traité Pratique du Développement: A. Londe (Paris, Gauthier-Villars).—Le Cylindrographe: P. Mëssard (Paris, Gauthier-Villars).—History of Higher Education in South Carolina: C. Meriwether (Washington).—Education in Georgia: C. E. Jones (Washington).—History of Education in Florida: G. G. Bush (Washington).—Higher Education in Wisconsin: Allen and Spencer (Washington).

CONTENTS.

THURSDAY, SEPTEMBER 5, 1889.

SIR WILLIAM THOMSON'S POPULAR LECTURES.

Popular Lectures and Addresses. By Sir William Thomson, LL.D., F.R.S., F.R.S.E., &c. In Three Volumes. Vol. I. Constitution of Matter. With Illustrations. ("Nature Series.") Pp. xi. + 460. (London: Macmillan and Co., 1889)

TO review a book by the leader of British physical science in the ordinary sense of reviewing would be absurd. To attempt an estimate of merit and demerit or to offer a superficial criticism might easily become an impertinence.

The object of a review in such a case as this is mainly to give persons who have not concentrated their attention on physics some idea of the nature of the book, so as to enable them to form a judgment how far it is suitable and accessible to them.

For, inasmuch as the greater part of what is published by the author of this book is stiff reading for trained physicists and mathematicians, and inasmuch also as the subjects of which he treats even in popular lectures are usually extremely abstruse, and such as require, if they are to be accurately stated at all, a very carefully-selected form of words and a rather involved construction of sentences, the idea may easily grow that anything by Sir William Thomson is mainly unintelligible. And unintelligible it probably is to the general public in their after-dinner arm-chairs. Unintelligible it quite possibly was to a large percentage of the audience in their after-dinner seats at the Royal Institution, though the personality of the man and the magnetism of his enthusiasm could hardly fail to enchain the attention of the most cynical or casual hearer.

In the printed book this personal charm is fainter; it is not absent—to those who have ever heard him the manner in which the illustrations are brought forward, the very tone of voice with which the sentences were delivered, are continually suggesting themselves—but it is fainter; and it becomes a question how far these lectures, which are undoubtedly scientific, are really popular, *i.e.* are really adapted to intelligent persons interested generally in the subject but who make no claim to be specialists in it. To answer this question I will run through the contents in such order as may be convenient.

About the middle of the book there is a quite popular and easy essay on the sense-organs of man, including that most important and fundamental sense—the sense of muscular exertion—without which it is doubtful if we should be conscious of an external world at all, insisting on a distinct sense of heat, and lumping together taste and smell; an essay in which certain much-needed clarifying statements are made to counteract some confusions introduced by more than one very popular book, as, for instance, the familiar difficulty about the relationship between light and radiant heat.

Next comes a lecture on the wave theory of light, delivered in America, giving to anyone who has attended a course of lectures or read some popular treatise on light a very good general notion of what is meant by the elastic-solid theory of the ether, and of the way in which the difficulties introduced by supposing light to consist of ordinary mechanical transverse vibrations of an elastic medium have to be met.

Then follows a perfectly beautiful series of discourses or articles on the age of the sun's heat, which, looked at from the point of view of the general reader, perhaps form the gem of the whole.

The cool collected way in which a possible and more or less probable way of forming our sun is gone into, with every detail clear-cut and closely reasoned out, forms a study than which nothing more instructive, more suggestive, and more wildly interesting is likely to be accessible with equal ease to the imaginative reader.

A sustained power of attention, a period free from interruption, and a power of forming vivid conceptions, are all that is needed for a comparatively uninstructed reader to receive some of the most splendid cosmical speculations of our time. He may not know exactly why when the two earth-like bodies start to rush together it is stated that they will meet in six months, or that the collision will last half an hour, and perhaps he may find some difficulty in picturing the equatorial zone or disk and the axial rod between which forms the mass will subsequently oscillate till it settles down into a globular and white-hot sun; but he may rest assured that none of these statements nor any such numerical statements met with in this book are random ones; they are all the result of exact mechanical knowledge and arithmetic, and whether they be precisely true or not, they are, at all events, righter than anything else he is likely to come across.

Irrespective of that on which stress is laid in the title, viz. the *age* of the sun's heat, we have in these essays a popular and very clear exposition of the solution of that long-standing puzzle—the means by which solar heat is maintained.

With lumps of matter of ordinary size (*i.e.* not incomparably greater or less than the human body) gravitation is a force altogether insignificant in comparison with chemical affinity, and accordingly while the combustion of a lump of coal transforms great quantities of energy, the force of gravitative attraction between two such lumps or between one lump and the oxygen it can combine with is so minute as to require a Cavendish and a Boys to demonstrate its existence to an audience. But with lumps of matter of sizes such as are found in the depths of space the case is quite otherwise. Between them gravitative attraction is furiously greater than any known kind of chemical affinity; and the work such masses can do in falling together, nay even the work one lump can do in slowly contracting upon itself, is sufficient to maintain radiation at the sun's prodigious rate.

Take a large enough mass of gas (*i.e.* of detached atoms), let its parts gravitate together continually, and you have a sun—a sun, moreover, obeying simple mechanical laws, and with a life-period, in its molten and therefore uncrusted and radiative state, of roughly calculable length.

It may be worth while parenthetically to remark that, whereas the chemical (or electrical) attraction between two atoms at any distance exceeds their gravitative attraction at the same distance more than a thousand million billion billion times, the atoms being regarded as spheres oppositely electrified each to about the potential of a volt, the gravitative attraction between two worlds the size and density of our earth exceeds their electrical attraction when likewise oppositely charged each to a volt in just about the same ratio. The ratio of the forces depends, in fact, on the fourth power of the linear dimensions of the bodies concerned—other things being fixed. For a couple of small bullets the two forces would be approximately equal.

Again, if every atom be regarded as separately charged, and able to combine with each other, we get the maximum possible energy of combustion, which may be put down as at the most 20,000 therms per gramme. The heat of formation of our moon by combustion is on this estimate very comparable to that developed by the falling together of its materials from infinity under gravitation. But whereas the energy of combustion is simply proportional to the masses concerned, the energy of gravitation is proportional to the product, *i.e.* to the second power of the masses; and so we find that when a body is as big as the sun the gravitative energy of its mere earthquake subsidence as it shrinks is enormously greater than that which could be afforded by the combustion of an equal mass. So also it is shown to be greater than could be caused by any reasonably permissible hail of meteorites from infinity: meaning by "reasonably permissible," such a hail as would not introduce planetary perturbations of a conspicuously non-existent amount.

Returning now to the beginning of the volume, we find an altogether admirable, but rather stiff discourse on capillarity. How it can help being stiff when it enters into problems usually treated by the higher mathematics, and hitherto reserved for specialists, I do not know. It is a serious mathematical essay done into ordinary language. The diagrams of the precise shape of liquid surfaces are beautiful, and such as are nowhere else to be found. To a reader who will concentrate his thought upon this discourse, it will gradually become luminously clear, but perhaps the conscientious person who always reads books from cover to cover, may run the risk of being choked off by the accident of its coming first.

Appended to it are three notes, one on the "tears of strong wine," as explained by Prof. James Thomson; one on the author's remarkable and beautiful discovery of the reasons why mist globules cannot form without a nucleus, why big rain-drops form at the expense of little ones, and why put-away clothes get damp; and lastly, a note on the sufficiency of Newtonian gravitation to explain cohesion. This latter is a highly ingenious piece of special pleading. It is so easy to prove that gravitation will *not* explain cohesion, on any of the commonly current mental ideas of what atoms are like; but here, by assuming a sufficiently violent concentration of substance in certain regions, and sufficient absence of all substance from other regions of an atom, it is shown that cohesion *may* be explained by gravitation. At least, it can be seen that different atoms can cling to each other, but it is not so clear how the various parts of the atoms themselves hang together. No-how, it seems to me, unless they are exaggeratedly fibrous structures, and unless the ends of the fibres of one atom cling on to the next, and thus build up a body like a cobweb. Nothing but cobweb can cohere by gravitation, so it seems to me (perhaps wrongly, of course); and although one has gradually learnt that no hypothesis concerning reality is *a priori* absurd or unlikely, yet this does not feel, nor indeed is it intended, as anything final or satisfactory.

Then comes a long lecture on electrical units of measurement, wherein the foundations of the conventional "absolute" systems of electrical measurement are explained and illustrated by showing how by means of electrical observations the fundamental standards of length, mass, and time might, if lost, be conceivably recovered. The subject is rather technical, and scarcely of sufficient general interest to repay the unelectrical reader, though there are here, as everywhere, numerous suggestive remarks. One might, perhaps, suggest that the distinction between the conventional and the essential is not always sufficiently borne in mind and enforced.

The lecture on the size of atoms is intensely interesting to everybody. Physicists know by how many different lines of argument a limit of smallness for the space occupied by an atom can be fixed, or an actual estimate of the number of molecules in a given lump of matter can be made. A number of these methods suggested by the author are here stated, and, with many illustrations, explained. But, besides this, there are instructive mechanical models or images illustrating Prof. Stokes's theory of phosphorescence, Cauchy's theory of dispersion, and the polarization of light by small particles.

The remaining subjects dealt with in this volume—elasticity regarded as a mode of motion, and a kinetic theory of matter—are closely related to each other, are wholly the author's own, and are among the most brilliant speculations of the century. But a small inkling of the great field thus opened up is given here—enough, however to afford to the reader some glimpse of the possibilities of development lying in this direction.

Such are the contents of the volume before us, and a more comprehensive collection of scientific addresses has seldom been published. They do not, of course, really represent Sir William Thomson at his best: neither they nor any other intelligible production of his is able to convey to the general reader an adequate notion of the magnitude of his solid work, or of the grounds for the veneration with which his contemporaries regard him.

Such as they are, however, every physicist will be glad to read these papers again in this handy form, and every intelligent and educated man who feels an interest in the strong thought of physical science during this eventful century will do well to make a serious effort to grasp at least the main outlines of the profound studies shadowed forth in this small volume. OLIVER J. LODGE.

THE MATHEMATICAL THEORY OF POLITICAL ECONOMY.

Éléments d'Économie Politique Pure. Par Léon Walras. (Lausanne: F. Rouge, 1889.)

THE appearance of a new and enlarged edition affords us a wished-for opportunity of calling attention to this original work. Its author is one of the favoured few to whom belongs the honour of having made a discovery in political economy. The title of Ricardo to the theory of rent is not better than the title of Prof. Walras to a theory more comprehensive than that of rent. It is a claim founded on originality rather than priority. Prof. Walras is the last of a small band of original thinkers who, in the latter half of this century, have independently excogitated the cardinal article in the doctrine of value. They have contemplated in different aspects the same fundamental conception: that value in exchange is neither simply identical with, nor wholly different from, value in use, but corresponds to the utility of the last, the least useful, portion of the commodities exchanged. "Nutzlichkeit des letzten Mengentheilchens," "Degree of Final Utility," "Grenznutzen," and "Rareté"—in different tongues and various terminology they proclaim the one essential truth which will be for ever associated with the names of Gossen, Jevons, Menger, and Walras.

This chronological, and, as it happens, alphabetical, arrangement is not identical with the order of merit. In that order we should place nearest together the names which are first and last in the series above written. Gossen appears to have been a mere specialist with few valuable ideas beyond the one which has made him immortal. Prof. Walras's light is more diffused. Yet it is true that we find in him rather *multum* than *multa;* that his principal achievement is the copious exposition of the one fundamental theorem to which we have referred. His next most important contribution to the stock of economic ideas relates to the function of the *entrepreneur*. Prof. Walras is one of the first who correctly conceived the *entrepreneur* as buying agencies of production (use of land, labour, and capital), and selling finished products in four markets, which thus become interdependent. His criticisms of the English school on this head are often valuable. Of the *entrepreneur's* funds, not pre-determined in the sense which some have imagined to any particular form of outlay, he well says:—

"Il serait aussi impossible de distinguer ce fonds de roulement du travail du fonds de roulement de la rente foncière, ou du fonds de roulement du profit, que de distinguer dans un bassin à trois robinets l'eau destinée à s'écouler par un robinet de celle destinée a s'écouler par les deux autres."

But surely he goes too far in the way of abstraction when he insists that the ideal *entrepreneur* should be regarded as "making neither gain nor loss":—

"Pour ce qui est de la part du profit constituant le bénéfice de l'entrepreneur l'école anglaise ne sort pas qu'elle est alcatoire, qu'elle dépend des circonstances exceptionelles, et non pas normales, et que, théoriquement, elle doit être négligée."

Perhaps his views on this and other points would have been more exact if he had considered the part which the "disutility" of labour—to use Jevons's phrase—plays as a factor of economic equilibrium, instead of confining his attention to "final utility." Another theory to which we ought to call attention is contained in the lesson on capitalization, which is added in the new edition. If the price of capital is determined by competition, it follows from the general theory of supply and demand that the maximum utility of all the parties concerned is realized in the same sense as in other markets. What is more than this in the newly-added theory has baffled us.

In the case just noticed and others, the argument is probably rendered obscure, or at least unattractive, by the use of symbols in excess of the modest requirements of elementary mathematical reasoning. The exuberance of algebraic foliage, rather than the fruit of economic truth, is the outcome of science thus cultivated. It is remarkable that the neatness which characterizes Prof. Walras's literary style, should not be reflected in his mathematical compositions. As an algebraist he has not attended to the maxim, *Il ne faut pas épuiser les choses.* We shall justify our criticism by referring to the chapters or "lessons," in which it is attempted to analyze what is called the "*tâtonnement*" of the market. The writer gives us three courses of this analysis. He diffuses over some thirty-five pages an idea which might have been adequately presented in a few paragraphs. For it is, after all, not a very good idea. What the author professes to demonstrate is the course which the higgling of the market takes—the path, as it were, by which the economic system works down to equilibrium. Now, as Jevons points out, the equations of exchange are of a statical, not a dynamical, character. They define a position of equilibrium, but they afford no information as to the path by which that point is reached. Prof. Walras's laboured lessons indicate *a* way, not *the* way, of descent to equilibrium. This is not the only topic with respect to which the laboriousness of the investigation is out of proportion to its importance.

Agreeing, therefore, in the main with Prof. Walras in his plea for the use of mathematical reasoning in economics, we fear that he may have prejudiced the cause by his advocacy. The excessive elaboration of his reasoning, compared with the simplicity of his conclusions, is calculated to excite suspicion. Moreover, he traduces the mathematical method when he applies it in such a manner as to justify the popular prejudice against abstract reasoning. He is surely *ultra crepidam*, he goes beyond the little hard matter with which the craft of the mathematician is concerned, when he offers opinions on the living organism of the industrial body, and the complexion of practical problems. His scheme of dosing the circulation by a nicely calculated injection of supplementary currency reminds us of the tailors in Swift's Laputa, who went through laborious mathematical computations in order to determine the measurements of a suit of clothes, which after all fitted very ill. When Prof. Walras offers us "the solution of the Anglo-Indian monetary problem," we think of Fluellen in the heat of the battle discoursing about the "discipline of the wars." There is a discipline adapted to the schools, and which it is profitable to have studied, but which has no direct bearing upon action.

A minor ground of complaint is formed by the extreme severity of our author's criticism, especially those which relate to the English school. We cannot think that Mill's oversights deserve the "*horribili flagello*" which is administered. To dismiss in a few lines "comme nul et non avenu" so much of that philosopher's reasoning appears to us rather slashing. But we are sensible that in condemning the unceremonious treatment of great men, we are laying down a law which applies to our own criticism of Prof. Walras. We shall therefore forbear to reduce our initial encomium by invidious reservations. When all that could be made are summed and subtracted, there would still remain to Prof. Walras the undoubted glory of an original discovery. He may say of that, as Napoleon of his victories, "*Il y a là du solide que la dent de l'envie ne peut ronger.*" F. Y. E.

MUSICAL INSTRUMENTS AND THEIR HOMES.

Musical Instruments and their Homes. By Mary E. Brown and W. Adams Brown. (New York: Dodd, Mead, and Co., 1888.)

THIS work should prove very useful to all who are interested in music and musical instruments. Primarily it professes to be a catalogue of the collection of musical instruments made by Mrs. J. Crosby Brown, of New York; but its value has been greatly augmented by a series of essays on the music and musical instruments of Oriental and savage races. The "catalogue" portion is well illustrated with clever pen-and-ink sketches, which give, for the most part, an excellent idea of the instruments, though they do not exhibit a great amount of detail. A brief description with dimensions, and, where possible, the native name, accompanies each sketch. The catalogue is divided into geographical sections, and at the end of each is added an essay treating of the music of the country from an historical and theoretical point of view, with a general account of the native instruments. Though these essays contain little that is new or original, they nevertheless form extremely useful compilations from a large amount of scattered literature; the references are full, and the list of authorities is a very representative one.

The sections devoted to China and India are of special interest, as dealing with regions which were the birthplaces of so many of the instruments in use amongst ourselves, changed though these be from their original forms. There seems little doubt, for example, that we owe the harmonium to China, and that instruments played upon with a bow had their original home in India, whither, too, we must refer the original use of "sympathetic strings."

Musical instruments, like all other products of man's handiwork, are subject to the laws of evolution, and each arrived at its present state by gradual stages of improvement. If the genealogies could be all followed back to the earliest stages, all instruments could be referred to such simple original forms as, for example, hollow or solid logs, reeds, or hunters' bows. With the rapid disappearance of the more primitive native instruments, the difficulty of tracing the history of music backwards by means of primitive "survivals" increases year by year. Every effort should be made to collect and place on record these simple forms, as from these we greatly derive our ideas of the "dawn" of music. The magnificent work by Hipkins and Gibb furnishes us with beautiful illustrations of *beautiful* instruments, but does not deal with the humbler kinds. The illustrations in the present work, therefore, are especially valuable, as the primitive instruments receive equal attention with the more elaborate. A very common error has crept into the pages of this otherwise excellent work—in the terminology. Nothing is more distinct than instruments of the "oboe" type and those of the "clarionet" type are from each other. These, though somewhat similar in general aspect, belong to different classes—the "double-reed" and the "single-reed" classes respectively; and any relationship must date back to the time when they each probably took their origin from a section of corn-stalk, the one form being sounded through the *pinched* end of the stalk, and the other through a *slit* cut in the end, and forming a *vibrating* or *beating* tongue. We find, however, in several passages a confusion of these terms. Thus, the Corean, Greek, and Spanish "clarionets," so called, are evidently "oboes," with double reeds for mouth-pieces. Similarly, the "pandeiro" of Madeira, not having a tense membrane, cannot be a "tambourine," however much it looks like one. The "mogugyo," or "wooden fish," of Corea and China, is called a "drum" in one passage (p. 80). But a "drum," too, *must* have a tense membrane, and an instrument ceases to be one if lacking this addition. The "mogugyo" is really far more closely allied to the "bell" series, though there is no general term which expresses this class of wooden instrument. Such mistakes are, doubtless, mere slips, but they are apt to be misleading.

In the description of savage music it is stated (p. 240) that the Mincopies have no musical instruments. This is not quite true, as they have one, though a simple one, and consisting merely of a hard-wood board, of special shape, which is used for sounding a rhythmical time for dancing. It is used only as a musical instrument, and so illustrates a step in advance of the Australian, who taps with a stick upon his "casting-board" for the same purpose, without employing a separate instrument.

It is to be hoped that other collectors will follow the excellent example of the authors of this work, and publish illustrated catalogues of their collections. We can hardly expect many such beautifully produced "catalogues," but the scientific spirit and easy style of this book might well be a model for others.

OUR BOOK SHELF.

Heat. By H. G. Madan, M.A., F.C.S. (London: Rivingtons, 1889.)

THIS is an elementary treatise of exceptional merit, combining thoroughly practical work with sound theoretical conclusions. The course of instruction which it comprises has been found suitable by the author, in his capacity as instructor at Eton College, for boys who already have some acquaintance with physiography and elementary dynamics. Mathematical expressions are accordingly used as little as possible, and, when used at all, they are fully explained in ordinary language.

A very large number of experiments—many of them new—are described, and we have the author's assurance that they are all capable of successful performance with moderate skill and care. It is rightly observed that experiments which do not always succeed, even with the greatest care, are altogether unsuitable for young students, as they invariably tend to make them lose confidence in the science.

Particular attention is given throughout to the application of the general laws of heat to the arts and manufactures, and to the phenomena of every-day life. The subject of ventilation, for example, is very fully discussed and illustrated by experiments. There is also a beautiful experiment illustrating the intermittent action of geysers (p. 195). Perhaps the most important application of the laws of heat, however, is the steam-engine; and most of the various forms, including locomotive and marine engines, are described. Even the gas-engine is briefly referred to.

There are no less than 138 excellent diagrams distributed throughout the text, most of which have been specially prepared for the book.

British Rainfall, 1888. By G. J. Symons, F.R.S. (London: E. Stanford, 1889.)

THIS work is a general summary and epitome of a year's work, and contains a Report upon the progress of rainfall investigations.

The volume is divided into three parts: the first deals with the measurement of snow, experimental gauges, the Camden Square evaporation experiments, and concludes with a list of the staff of observers, showing that the staff is still on the increase, although very slowly, the chief increase being in England.

The second part treats of the rainfall and meteorology for the year, as reported from the various observing stations. One of the heaviest short-period rains recorded is that which fell on March 24 at Chepstow, Shirenewton Hall; it lasted two minutes, and in that time the ground was covered 2 inches deep with snow, the flakes being 3¾ inches in diameter, and only ¼ inch thick, 6 inches of this snow yielding 1 inch of water, so that, if the snow had lasted one hour, it would have reached an average depth of 5 feet.

Maps and tables indicate the monthly rainfall for the year, the greatest fall being at "The Stye," in Cumberland (175·40 inches), the least at Skegness, in Lincolnshire (17·50 inches).

Lastly, Part III. consists of general tables of the total rainfall at the 2500 places of observation.

Putting together all the above facts, we find that during the year there was much dry weather, although few droughts; there were hours and days of excessive rain, months with amounts of rain almost without precedent. Yet, on the whole, we get a result not at all remarkable, but decidedly below the average.

Rainfall observers will find in this book a collection of most interesting tables, maps, and articles upon the various branches of the work; and as the new decade begins with January 1 next year, we hope that the staff of observers will number many of our readers among them.

Ancient Art of the Province of Chiriqui. By W. H. Holmes. (Washington: Government Printing Office, 1888.)

THIS is an extract from the sixth Annual Report of the U.S. Bureau of Ethnology, and will be read with interest by all students of American antiquities. Chiriqui occupies a part of the Isthmus of Panama, and at the present time is inhabited chiefly by Indians and natives of mixed blood. Many ancient cemeteries have been discovered along the Pacific slope of the district, and explorers have found in them a great quantity of more or less valuable objects of art. These objects Mr. Holmes has classified, and in the present monograph he carefully describes the characteristics of typical specimens. He first deals with the graves and their human remains, then passes on to consider, in order, objects in stone, objects in metal, and objects in clay. His descriptions are concise and lucid, and their value is greatly increased by a large number of excellent illustrations. Mr. Holmes is careful to point out that there is no valid reason for assigning a very high antiquity to the works of art found in Chiriqui. The tribes by whom the graves were made may, he thinks, have been in possession of the country, or parts of it, at the time of the conquest. Their pottery appears to indicate that they were more closely related with the ancient Costa Rican peoples than with those of continental South America; but in their burial customs, in the lack of enduring houses and temples, and in their use of gold, they were, as Mr. Holmes shows, like the ancient peoples of middle and southern New Granada.

An Elementary Treatise on Dynamics. By Benjamin Williamson, F.R.S., and Francis A. Tarleton, LL.D. Second Edition. (London: Longmans, Green, and Co, 1889.)

THIS work has been thoroughly revised, and a considerable alteration has been made in the order of its arrangement. The first half of the book treats of the dynamics of a particle, while the latter part deals with kinematics and kinetics of rigid bodies.

Many portions of the subject have been developed, and in some cases rewritten, especially that on generalized co-ordinates in connection with Legrange's and Hamilton's methods; the general theory of oscillations is exhibited in a new form.

The work has been arranged from the most elementary conceptions, so that anyone acquainted with the conditions of equilibrium, and with the notation of the calculus, may commence the treatise without studying any other book on the subject.

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.*]

On some Effects of Lightning.

DURING the thunderstorms of the 6th and 7th of June last, some twenty trees and buildings were struck within a 5-mile radius from Cranleigh. I have examined most of the trees struck, and have found a remarkable similarity in the effects, which are of two kinds: the first, by far the most common effect, is simply a score out of the bark up the trunk of the tree, out along one limb, and then by perhaps two or three smaller branches to the outer twigs; the other effect is the shattering of the tree, which occurs, as Mr. Griffith remarks in NATURE of August 15 (p. 366), when the lightning course leaves the outer surface of the tree and enters between the bark and the wood at the junction of some main branch with either the stem or with some other branch, when the shattering would probably occur from some obstruction at the junction, or from there being water in a cavity or in a collection of dead leaves in the fork.

I imagine that in general the course of the electricity is outside of the bark, following one or more lines of moisture or running water down the tree; when this conductor becomes insufficient a discharge takes place, and the stream of water is converted into steam so violently as to destroy the bark instantly along the line of strain. If the sap within be also converted into steam by communication through a knot-hole or by a flaw, the bark is blown off altogether.

If the tension be very great indeed, and especially if the air round the tree be dry, the sap may be violently exploded, and the trunk splintered and shattered as if by dynamite.

Most of the trees in this neighbourhood were struck while it was raining; but one tree, a Scotch fir, occupying a prominent position on the side of a hill, was struck before any rain fell. This tree divided out into two arms nearly in line with the stem; one arm was thrown to the ground, the other remained up for a few hours, and was then blown down by the wind, falling in the opposite direction to the first arm. At the junction there was a great deal of turpentine which was thoroughly blackened. The trunk below the arms was shivered, and the bark thrown out to a distance very similarly to the case related by Mr. Griffith. One curious feature in the present instance was that the roots of the tree could be traced to a considerable distance by the earth above them being thrown up as over a mole barrow.

Most of the trees struck here have been oak; but there were also two poplars, four elms, a chestnut, and the fir above mentioned. It is said that beech-trees are never struck: probably the smooth close-fitting bark makes a better conductor than the rough bark of the oak. J. P. MACLEAR.

Cranleigh, August 26.

Nose-Blackening as a Preventive of Snow-Blindness.

IN vol. xxxviii. of NATURE there were several interesting letters on this subject. Will you allow me to suggest a possible explanation?

For some years past I have interested myself in the choroidal circulation, and my observations have led me to believe that when light is absorbed by the choroidal pigment the blood-supply at that spot is increased. If the light is intense, this increase soon has the effect of blurring the image, and if at the same time the light is intense and the exposure to it prolonged, the sensitiveness of the retina may suffer for some time after from the same cause, *i.e.* an abnormally large blood-supply in the choroid.

In the course of the blood-vessels there is just such a connection between the retina and the skin as the nose-blackening preventive requires. My suggestion is that the blackening of the skin increases its demand for blood in some way, perhaps by its increase of temperature, and that thus a larger supply is drawn along the main branches of the ophthalmic artery, the naso-frontalis, the supra-orbitalis, and the lacrymalis, diminishing the quantity which finds its way into the small and almost independent system of the choroid. In this way nose-blackening would save the retina from being oppressed and injured in the way mentioned.

I may mention that if anyone after walking for an hour or so in the snow covers his eyes so as to exclude all external light, he will find his eyes filled with a very bright retinal light, and also if he is at all accustomed to see the blood corpuscles moving in his field of vision he will see them at such a time very distinctly and in great numbers by looking at the sky.

The theory which my observations have led me to form, that there is a very intimate connection between the retinal light and the circulation in the choroid is almost necessarily crippled by the fact that it rests largely upon subjective phenomena which are misleading, are not demonstrable, and depending on the constitution of the subject are not readily confirmed. Until, therefore, I can hear of another worker in the same field whose observations agree in the main with my own, I do not feel prepared to publish them. HENRY BERNARD.

Jena, August.

A Method of Mounting Dried Plants.

AN example of a very useful and expeditious method of mounting herbarium specimens adopted here is inclosed as worthy of attention. Short strips of lead, used in packing tea, are passed through slits in the paper on each side of the part of the plant to be fastened, and the ends then bent flat out on the back of the sheet. The many advantages of using this, or some other pliable metal, in certain cases, are very obvious. Has this method been hitherto suggested? JOHN WILSON.

University, St. Andrews.

COLOUR-BLINDNESS AND DEFECTIVE FAR-SIGHT AMONG THE SEAMEN OF THE MERCANTILE MARINE.

IN the House of Commons, recently, attention was called to this subject by Dr. Farquharson, who, in stating that he would take an early opportunity of discussing it next session, intimated that the efficiency of the Board of Trade regulations on this matter was open to grave suspicion. On making inquiry, we find his doubts are only too well founded. When, in the year 1852, the carrying of red and green side-lights by sailing-vessels was made compulsory, the subject of colour-blindness had not awakened the attention of practical observers. Had the fact that from 3 to 4 per cent. of the whole male population are colour-blind then been known, it is possible that some mode other than by showing red and green lights would have been devised to indicate the positions of vessels at sea at night. As there is generally but a hazy conception of what is meant by the term colour-blind, we will briefly indicate its exact significance.

When, in 1794, the distinguished chemist, Dalton, published a description of his sense of colour, the scientific world were surprised to find that there existed individuals whose perception of colour differed in a remarkable way from that of their fellow-man. To have said that an individual possessed the sense of sight was tantamount to saying that he possessed the sense of colour, the latter being considered an integral part of the former; but Dalton's report clearly showed that the two senses were separate and distinct, and that, while an individual might have a perfect appreciation of form, he might also be quite unable to perceive any distinction between two or three or more distinct and different colours. Further investigation showed that there were a few people who could discern no colour at all, every object appearing as black or white, or as shades of black and white (grey). This is total colour-blindness, and is very rare. The usual form, and that which we allude to when we speak of a colour-blind, is that in which the individual can distinguish the colours blue and yellow, but can see no difference between the colours red, green, and brown; and from the fact that one of these individuals, if given a vivid scarlet skein of wool, will select to match with it green skeins and brown skeins, it follows that he must see green and scarlet as he sees brown. Now, there being between 3 and 4 per cent.[1] of the whole male population afflicted with this variety, it follows that a very large section of the community are by nature disqualified for all those positions in which the correct interpretation of coloured lights is essential to safety. Clear as this fact must be, it was not until Dr. George Wilson, of Edinburgh, in the year 1855, published his admirable work, entitled "Researches on Colour-blindness," that public attention was invited to the subject. He showed with the greatest clearness how the safety of a vessel lay in the hands of men—"look-outs," officers, and pilots—who might be colour-blind, but were unconscious of this defect, or afraid to confess it; and he came to the definite conclusion, as the colour-blind were in a minority in the community, therefore, those destined to deal with signals should be selected solely from the majority whose vision was normal, and he earnestly urged upon those in authority the necessity of excluding colour-blind men from the sea profession.

One sentence was prophetic, that in which he says "the appalling yearly list of lost vessels which appears in our Wreck Returns awakens the suspicion that more than one of these fatal disasters may have resulted from the mistaken colour of a lighthouse beacon or harbour lamp, which on a strange coast, and with the accompaniments of a snow-storm or a thick fog, has been wrongly deciphered by a colour-blind pilot."[2] And if true of the pre-steamship days when vessels carolled along at the rate of a few miles an hour, what is to be said of the present time, when our "greyhounds" of the ocean flash along at the rate of twenty miles an hour, day and night? The regulation red and green lights of a steamer are

[1] Holmgren examined 32,165 men: 1019 colour-blind—3·168 per cent. Joy Jeffries examined 10,387 men: 431 colour-blind—4·149 per cent. London Committee examined 14,846 men: 617 colour-blind—4·156 per cent.

[2] Colour-blindness proved to be the cause of *Lumberman* and *Isaac Bell* collision: ten lives lost. Colour-blindness proved to be the cause of loss of *City of Austin*—colour of buoys was mistaken: money loss £40,000. Colour-blindness or defective sight was the cause of collision between *Carbet Castle* and *J. H. Ramier*: money loss £1900.

supposed to be seen at a distance of two miles. Take the case of two steamers going in opposite directions at the rate of twenty miles an hour. It follows that from the very moment of those on board being aware of each other's position, but three minutes will elapse before they meet. Is not this little enough time to alter a course? And this is premising a clear atmosphere. Should the night be hazy, the oil poor, the wick badly trimmed, or the glass dirty, the distance at which the light can be seen is lessened, and the time to alter a course correspondingly diminished. Add to this the presence of a colour-blind or defective far-sighted "look-out" or officer, and there is present every attribute for the accomplishment of those terrible tales of the sea which year after year greet us with an alarming regularity. The *Times* (February 5, 1889), in reporting the terrible collision which occurred in the channel, *in fine clear weather*, in which both vessels (s.s. *Nereid* and s. *Killochan*) went to the bottom in less than five minutes, carrying to a watery grave twenty-three men out of a total of forty-two, remarks: "All inquiries respecting the cause of this disaster lead to the same conclusion, that it was due to one of those astounding errors of judgment on the part of one or other of the navigators which seem to defy all attempts at reasonable excuse." Read in the light we suggest, and the cause is as clear as daylight.

The same may be said of the terrible collision, when, again on a *perfectly clear night*, the s.s. *Douro* and the s.s. *Yrurac Bat* both went to the bottom with more than two score of their living burden. And who can say that the loss of the s.s. *Ville du Havre*, with its appalling death-roll, was not directly due to the colour-blindness of "look-out" or officer on one of the colliding vessels? We know how the inquiry ended. The English Admiralty decided that the English vessel was free from all blame, and the French Admiralty declared that the French vessel could not be in any way incriminated. But no one thought of attributing the mistake to the very probable one of colour-blindness. Now, what are the precautions taken to guard against those dangers which the employment of "colour-blind" and defective far-sighted sailors renders possible? We reply advisedly and after careful inquiry, "Practically none." It is true that twenty-two years *after* Dr. Wilson had so graphically described these dangers, the Board of Trade authorities awoke from their long sleep of indifference, and said that they recognized "the serious consequences which might arise from an officer of any vessel being unable to distinguish the colour of the lights and flags which were carried by vessels," and they instituted "tests and regulations," the value of which will be indicated by the following facts. The regulations do not prevent colour-blind "look-outs," colour-blind pilots, colour-blind A.B.'s, or colour-blind apprentices remaining sailors to the end of their days. They do not prevent colour-blind first mates or colour-blind captains and masters retaining their positions also to the end of their days; nay, more, they actually give colour-blind officers certificates that they are not colour-blind.

Should anyone doubt these grave statements, let him read the Board of Trade Reports for 1885, 1887, and 1888. He will find there that no less than forty-five officers rejected for colour-blindness were eventually given unendorsed certificates, which is identical to saying these men were not colour-blind, and that they were perfectly capable of taking charge of the lives of hundreds of helpless passengers, and of property to the extent of thousands. Is not this little less than a public scandal? We who know that colour-blindness is congenital and incurable, know either that these forty-five men were not colour-blind when rejected, or that they are colour-blind to-day. Which contention is the more likely may be gathered from the fact that, of these legalized non-colour-blind men, according to the Board of Trade's own reports, four were unable to distinguish red from green, twenty-two more called the colour red green, five others called the colour green red, and the remainder made mistakes of a marked character.

The Board of Trade so-called "tests for the detection of colour-blindness," viz. the requiring candidates to give the *names* of coloured cards, and lights shown them—tests which are stated to be "sufficient to prevent anyone who is more or less (!) colour-blind escaping detection by the examiner"—may be tests of a man's education in the *names* of colours, but as tests of the colour sense, they are not trustworthy, and tests which are not trustworthy are worse than no tests at all. Practically, the "tests" are barely worth the paper they are printed on. And the "regulations" dealing with a colour-blind officer, should he be detected, are of a like character, a snare and delusion. The public and the shipowners believed, rightly or wrongly it matters not, that the regulations were framed to absolutely keep colour-blind officers out of the sea service. They do nothing of the sort. With regard to the far-sight of a sailor or officer, there are no tests at all; a man may be the subject of any of the various forms of eye-disease, may have any degree of blindness, or may be so shortsighted as to be unable to see distinctly more than a few inches in front of his nose, and yet be at perfect liberty to be a sailor to the end of his days, or to become an officer. Are the public going to allow this grave condition of affairs to remain as they are? We answer emphatically "No," and we feel sure that when Dr. Farquharson brings the subject forward, the House of Commons will insist that the Board of Trade authorities who have the duty and privilege of providing for the safety of the travelling community of the first maritime nation of the world, will take, even though thus late, such precautions as will insure to the sea traveller immunity from those dangers which the present employment of colour-blind and defective far-sighted sailors renders possible.

ST. ELMO'S FIRE ON BEN NEVIS.[1]

ST. Elmo's Fire as seen occasionally at the Ben Nevis Observatory takes the form of jets of light on the tops of all objects that stand any height above the general level of the roof of the Observatory, such as the chimneys, anemometers, lightning-rod, &c. In a very fine display the tops of the objects are quite ablaze with the phenomenon, which then glows and hisses in brilliant tongues of white and blue, from four to six, or even more, inches in length. Nor is the phenomenon confined to these objects alone in the finer displays, but if the observer stands on the roof his hair, hat, pencil, &c., glow with it as well, and when he raises a stick above his head the stick has also a long flame at the top. Further, however, than having a slight tingling in his head and hands he suffers no inconvenience. The hissing is a very marked characteristic of the phenomenon, being always heard during ordinary displays, though in the feebler displays, when the light can barely be seen, it cannot be distinguished from the hissing of the wind and the snow drift. On one occasion the sound was a very highly pitched note. In the finer and even in ordinary displays St. Elmo's Fire is an object of great beauty, and the stormy character of the weather—namely, squally winds with heavy showers of snow and hail, and with clouds of snow-drift flying all around—heightens rather than diminishes the effect, although at the same time it detracts from the convenience of observing with advantage.

Up till the summer of 1888 fifteen cases of St. Elmo's

[1] Abstract of a paper on "St. Elmo's Fire on Ben Nevis," by Angus Rankin in the Journal of the Scottish Meteorological Society, third series, No. v.

Fire were noted at the Observatory, and these occurred all in the night-time, and all during the winter months, beginning with September and ending with February. The feebleness of the light it gives forth, in comparison with ordinary daylight, makes it difficult if not impossible to see it during the day, which is probably the reason for its being a nocturnal phenomenon, and partly for its being a winter phenomenon, for the short summer nights greatly lessen the chances of seeing it. Other reasons for its being a winter phenomenon, and not a summer one as well, are that the high temperature in summer is not favourable to its appearance, and that the weather type in which it appears is far more common in winter than in summer. The fifteen cases are distributed throughout the winter months as follows: two in September, three in October, five in November, two in December, one in January, and two in February. An investigation of these cases, and of the meteorological observations made before and after each appearance of St. Elmo's Fire, has shown that the weather which precedes, accompanies, and follows it has very definite characteristics, not only on Ben Nevis but also over the whole west of Europe. What these characteristics are will be briefly explained in what follows.

To arrive at a knowledge of the conditions obtaining on Ben Nevis, the observations of pressure, temperature, wind direction, and rainfall, made at the Observatory, were tabulated for each hour from thirty hours before to twenty-four hours after the appearance of the phenomenon in each case. The general averages thus obtained for the whole fifteen cases for each element give very decided curves. They show that, as regards pressure, the barometer, from being 24·993 inches at thirty hours before St. Elmo's Fire is seen, steadily falls till the sixth hour before, when it is 24·771 inches, and thereafter rises till the twenty-fourth hour after the display, when it is 24·979 inches. At the hour at which St. Elmo's Fire is seen and the following hour, however, a slight dip is indicated in the ascending curve. Taking all the pressure averages into account, they indicate a well-defined depression, in which St. Elmo's Fire is seen six hours after the centre, or point of lowest barometer, has passed. It is important to note that all the pressure averages come out below 25·000 inches, because this indicates that the depression occurs while Ben Nevis is in an area of general low pressure—the mean barometric pressure at the Observatory for the four years ending 1887 being 25·296 inches.

The temperature averages show a broad maximum from twenty-four to sixteen hours before and a minimum sixteen hours after St. Elmo's Fire is seen—the range being 3°·7; and between these hours there is a continuous fall in the temperature. The rate of fall is greater before than after the display. In some of the cases the range is much greater than 3°·7—in one it is 13°·4. It was chiefly from the observations of temperature that we were able on several occasions to give successful forecasts of the appearance of the phenomenon several hours before it occurred.

The chief points shown by the wind-direction averages are, that they all belong to the western half of the compass; that till the tenth hour before St. Elmo's Fire is seen the wind blows from a south of west direction, and thereafter from north of west; and that from the twenty-fourth hour before St. Elmo's Fire is seen, when the direction is south-west, the wind steadily veers till the fourth hour before, when it is west-north west, which it continues to be till after the appearance of the phenomenon, and goes on veering again till the tenth hour following, when it is north by west. This veering of the wind before St. Elmo's Fire is seen is well marked in all the cases.

The rainfall averages show two distinct maxima, the first between ten and six hours previous to the display, and the other at the hour St. Elmo's Fire is seen and the following. The latter maximum is wholly due to the heavy showers of snow and snow-hail that accompany the displays. This snow-hail differs from the usual flaky snow crystals in being of the shape of small cones with spherical bases, and being hard and dry. During the finer displays this kind of snow was always present.

Thus, as far as local observation goes, we see that St. Elmo's Fire is seen on an average six hours after the lowest reading of the barometer has been recorded, in a depression that occurs in a general low-pressure area; that it is preceded, accompanied, and followed by a falling temperature; that before it is seen the wind has veered considerably, and goes on veering for some time after its appearance; and that it is attended by heavy precipitation in the form of snow-hail.

The averages are of some interest apart from their connection with St. Elmo's Fire, for they show the relations existing in this class of storms between the four elements here discussed. The averages of pressure and of the direction of the wind are sufficient to show that the depression comes in from the Atlantic, and that the centre passes eastwards somewhere to the north of Ben Nevis. Then it is seen that the temperature is at a maximum when the barometer is falling, and is still falling when the barometer is at its lowest; that is, at a time when the atmosphere is very unstable and ascending currents at their strongest, the temperature is falling on Ben Nevis, a state of matters that must necessarily result in a rapid condensation of vapour, and a consequent copious precipitation. The rainfall averages quite agree with this.

As to the prevailing weather over the British Isles and west of Europe in general, about the times of St. Elmo's Fire being seen on Ben Nevis, the weather charts of the London Meteorological Office show that, in almost all the cases, the following conditions obtained—namely, somewhere to the south or south-east of the British Isles, usually over the south of France and over the Spanish peninsula, there was a distinct high-pressure area, or anticyclone; and that to the west or north of Scotland there was a low-pressure area, or cyclone. Between these two positions the barometric gradient was chiefly for south-westerly to westerly winds, and was usually pretty steep. The charts also showed that, so long as the anticyclone maintained its position to the south-east, so long did cyclones sweep in from the Atlantic with the above gradient wind, and pass our islands in a north-easterly or easterly direction. Thunder and lightning were noted in Ireland on several of the nights that St. Elmo's Fire was seen on Ben Nevis. Only on one occasion was any thunder and lightning observed on Ben Nevis, about the times of St. Elmo's Fire appearing, and then the phenomenon was seen two hours before the thunderstorm came on.

It might be inferred, from what has been said, that as St. Elmo's Fire appeared at the change of weather, when the centre of the storm had passed, it would be a good prognostic of improving weather. Such is not the case, however, for almost invariably another cyclone is approaching, and another spell of bad weather is experienced soon after the St. Elmo's storm has passed.

A. R.

NOTE.—Since the paper, of which the foregoing is an abstract, was written, several additional cases of St. Elmo's Fire have been observed on Ben Nevis. On one occasion we were fortunate enough in securing a photograph of the phenomenon, which shows St. Elmo's Fire as three small spots of white on the top of the kitchen chimney, the chimney being but very faintly seen.

TELESCOPES FOR STELLAR PHOTOGRAPHY.[1]

I.

I WILL ask you to remember that the subject of this paper is not that of the proposed international photographic survey of the heavens itself, but of the instruments which are to be used for that survey. No doubt a communication on the survey itself, dealing with the results aimed at, the conditions under which it is considered the best results may be arrived at, and the general scheme under which it is proposed to measure, define, and catalogue the position of the stars obtained, would be more generally interesting than one on the mere instrumental equipment; but this part of the subject has already been amply and most efficiently dealt with in lectures by Mr. Common and Dr. Gill at the Royal Institution, while the subject of the instruments to be used has only as yet been discussed in the more scientific and technical journals or proceedings of Societies; besides which, I may be pardoned for saying that I think when actual work is commenced, the perfection of the instrumental equipment will be found to be a larger factor in the attainment of success than has ever been the case in any previous astronomical research. There is probably nothing which surprises and excites the admiration of the modern astronomer more than the work done in bygone times by some of the older astronomers—work which was the outcome of marvellous patience and ingenuity while working with tools which would excite the pity and contempt of the merest tyro in astronomy of the present day; but while I am by no means a sceptic as to the most important part of all telescopes being "the man at the small end," I do believe that never before in any system of astronomical observing has "the man at the small end" been so completely dependent on the excellence of his instrumental equipment, a disarrangement of any one part of which would leave him utterly helpless. I trust, therefore, you will bear with me while discussing and describing a few of the more important mechanical details of these instruments.

You are aware, probably, that an International Congress of Astronomers was held last year in Paris, and that it was decided to start a number of Observatories, in various parts of the world, each to take its share in producing photographs of the heavens, to be afterwards used in compiling a general chart, in which stars down to the 14th magnitude would be entered.

Before we go further, it may be well to explain the difference between this system of charting and the old system, and what circumstances have led to this proposed revolution in astronomical work.

The system of mapping stars which has been used up to the present time consists, as you are aware, in observing all the stars *seriatim*, in a transit circle, or similar instrument, and tabulating their declination (*i.e.* angular distance north and south of the equator), or Polar distance, as found by readings of the vertical centre, and their right ascension (*i.e.* their distance measured on the equator from an empirically fixed point in the heavens), as found by the difference of time of the sidereal clock between the passage of the star across the centre wire of the telescope and that of the fixed point above referred to. The essential point in the above system which I have to direct your attention to is, that every single star has to be examined *by itself*.

The magnitude of the work of such a survey as the Paris Congress has decided upon may be inferred from the fact that there are probably some 20,000,000 stars to be examined and catalogued. It is a good year's work of a transit circle to tabulate 5000 stars; supposing, therefore, thirty or forty Observatories divide the work between them, the survey would still occupy over 100 years, and by that time the proper motion of the stars would render a new survey necessary.

Now, ever since photography has been practised, it has been the dream of the astronomer to photograph the heavens, and obtain, at one and the same time, the positions not of one but of hundreds, or perhaps thousands, of stars in each operation. But then, it may be asked, why was not photography employed long since? The answer is, that until recently the amount of sensitiveness obtained was not sufficient to allow of the fainter stars impressing the plate within reasonable time, and consequently it was found impossible to produce satisfactory stellar photographs, except of the larger stars.

Dr. Warren De la Rue was the first to point out the use which might be made of photography for the purpose of star-charting, and, as far back as 1860 and 1861, produced photographs of star-clusters, &c.

In 1864 or 1865, Rutherford, of New York, obtained photographs of the larger stars, and while photographing the moon with the great Melbourne telescope in 1867 I took, for the purpose of adjustment, some photographs of "Castor"; but in an article which I wrote for the "British Journal Photographic Almanack" in 1869, I pointed out that for the development of celestial photographs we would have to look to the chemist and not to the optician—in other words, that until we obtained more suitable plates we could not expect much advance. This has proved to be the fact, for with the advent of the gelatine plates, and consequent increase of sensitiveness, celestial photography received that impetus which has eventuated in this proposition of an international photographic survey. I also pointed out in that same article nineteen years ago that if by any possibility the exposures could be reduced so far as to render the unsteadiness of the image insensible—a rapidity which I said there was no reason to suppose might not be obtained in the case of the sun—we might expect great results, a prediction which has since been verified by Prof. Jansen's magnificent pictures of the sun, with which you are all familiar.

It is almost superfluous to remind you also of the magnificent picture of the nebula in Orion by Mr. Common, an example of celestial photography never yet surpassed.

In 1882, Dr. Gill sent home to the Royal Astronomical Society, and to the Paris Academy of Sciences, a photograph of the great comet of that year, and called attention to the large number of stars photographed on the same plate. This photograph was obtained with an ordinary photographic lens and camera attached to a clock-driven equatorial.

It was this, perhaps, that influenced the Paris Observatory to construct the photographic telescope of about 13 inches aperture, 11 feet focal length, specially corrected for the chemical rays, with which the splendid star charts of the Messrs. Henry were obtained. Meanwhile, others were not idle, and while Dr. Gill, through the munificence of Mr. Nasmyth, obtained a 9-inch achromatic, which I corrected of course for the chemical rays, Mr. Roberts, of Liverpool, had a 20-inch reflecting telescope constructed for the same purpose.

It soon became evident that this new departure in the system of star-charting was likely to be of very great importance, and consequently an International Congress of Astronomers assembled last year in Paris to discuss the whole question. This Congress defined the size and focus of the object glasses to be used, and laid down a certain standard for the correction of the chromatic aberration suitable to the nature of the work; but left almost all other points free for individual astronomers to deal with as they thought best. In fact, the Congress wisely defined only just such points as were necessary for securing uniformity in the scale of the photographs, all of which it is proposed shall be sent to some central bureau to be examined, discussed, and made use of in compiling the chart.

[1] A Paper read by Sir Howard Grubb, F.R.S., before the Society of Arts, on April 18, 1888.

But it may be asked where is the great difference between this system and the old, as the positions of the star images on these photographs have to be measured *seriatim*, just as the stars themselves have to be measured *seriatim* in the old system. This is no doubt true, but under what different conditions are the measurements made.

None but those who have worked in this field know the labour represented by a volume of 5000 star places under the old system.

How many times does that wretched bit of cloud come across the field just as the star reaches the centre wire of the micrometer, and how many nights, beautiful and clear as they may look to ordinary individuals, prove utterly worthless for observing purposes; but under the new system, once a single good plate has been obtained, there is a permanent record of some hundreds, or in some cases thousands, of stars, which can be measured at leisure by day or by night, in good weather or bad weather, and in comfort in your office or study, and there also is that photograph as a permanent record which can be referred to at any time as a check on errors which might possibly creep in to some of the final reductions.

In fact, this new system gives us the means of taking advantage of the very few really favourable opportunities of observing, and of producing, during those favourable moments, a *facsimile*, so to speak, of any portion of the heavens which we can examine and survey at our leisure without any of the difficulties or discomforts attendant upon direct astronomical observations, and under conditions far more favourable to the obtaining of accuracy in the results.

Let us now consider what are the chief points to be attended to in the construction of the instrument. It is evident that what is required is an instrument which—

(1) Can be accurately pointed at any given object.

(2) That when pointed in the desired direction the clockwork shall cause it to follow that object as steadily as possible.

(3) That as the meridian is the best position for observation, the instrument should be capable of working for some distance on each side of the meridian without reversing.

(4) That means should be supplied by which the observer can watch and verify the accuracy of the clock-driving, or making any change in position rendered necessary by refraction.

The first point involves delicate and accurate slow motions in right ascension and declination.

The second involves great steadiness and rigidity of the mounting, great smoothness of motion of the polar axis in its bearings, and above all most accurate clock-driving motion.

The third point involves either the adoption of the old English form of mounting, or a modification of the German form, as the latter does not generally allow of motion for any considerable extent beyond the meridian without reversal.

The fourth merely involves a very powerful finder—or, rather, guiding—telescope with suitable micrometric eye-piece arrangements.

Respecting the relative merits of refractors and reflectors for this purpose, I shall speak just now; for the present I wish to direct your attention to the instrumental part only, and, for the better understanding the peculiarities of the various mountings, I will now throw photographs of some of them on the screen.

The first illustration is that of the Paris equatorial, with which the well-known and deservedly praised star pictures of the Messrs. Henry were produced. You see it is of the construction generally known as the "English" equatorial,—a long split polar axis, with bearings for carrying the telescope at the centre (its weakest point). This form of equatorial has many advantages, which at first seem to render it peculiarly fit for this special work. With good slow motion, and a large finder telescope, it admirably fulfils the first, third, and fourth of the above conditions; but, owing to its peculiar form, and the difficulty of using a driving sector of long radius, it is not well calculated to fulfil the second and most important of all conditions, viz. the accurate following. No doubt excellent work has been done with it by what is called the "eye and hand" guiding. That is, the star is watched in a powerful finder, and when it is seen to err sensibly in position, it is brought right again by the slow motion handle. I think it is generally allowed that the undoubted excellence of the work done by the Messrs. Henry is due more to extraordinary patience and skill in the "eye and hand" guiding than to any unusual perfection of the clock-driving. This form of instrument also possesses a disadvantage in being very difficult to arrange for work near the Pole.

The second illustration is of Dr. Gill's 9-inch photo telescope, with which he took his star pictures. There is nothing peculiar about the mounting of this, being in fact an old equatorial which I sent him some years since. In this case also the excellence of his results is to be attributed to the skill of the observer, and not to any inherent excellence of the clockwork; but that excellent work has been done with it is apparent from the perfection of some of his photographs.

The next illustration is that of the telescope of Mr. Isaac Roberts, of Liverpool, for whom I mounted a 20-inch reflector to experiment with. As you see, it is mounted on what I call the twin form, as I mounted Dr. Huggins's instrument, by the adoption of which the observer always has a second telescope available for visual work, if anything interesting should appear in the heavens. With this instrument Mr. Roberts, working in the exceptionally wretched atmosphere of Liverpool, has secured some most admirable work, a few specimens of which I now throw on the screen.

This is the first instrument, as far as I know, in which a successful attempt has been made to drive, for any considerable time, without "eye and hand guiding." The special system of clockwork used I will describe further on. So far as the general form of the instrument is concerned, it would appear that the balance of advantage lies with the German form (so called) — that usually adopted in this country. It is capable of being made of great stability, and it admirably fulfils all the conditions except the third, but that also, by a little modification, can be managed.

The next illustration shows the general form which I have adopted, the principal feature of which is great stability. The stand being cast all in one piece contributes to this, but the peculiarity of the system of equipoise probably has more to do with it. In designing these instruments, I proposed that the fulcrum of the levers which support the greater part of the weight of the polar axis, should be attached, not to the frame of the instrument, but to an independent pillar, so that only a very small portion of the weight of the moving parts should be carried by the main framing. Dr. Gill then proposed that I should also allow the levers to act in a purely vertical direction, instead of, as usual, in a direction at right angles to the polar axis, and to let the point of support be vertically under the centre of gravity of the whole moving part. This I have carried out, and the result is that only as much of the weight of the whole instrument as is necessary to insure steadiness will rest on the bearings (lateral or end bearings) of the polar axis; all the rest is transferred to the base of the stand.

We now come to consider the all-important part of the photographic equatorial—that is, the driving clock.

All clocks used for driving equatorials (which must of course move uniformly, and not step by step as pendulum clocks), may be divided into two classes—(*a*) those in which uniform motion is obtained, or sought to be obtained, by some variable friction or resistance which increases as the speed increases; and (*b*) those in which some such similar contrivance is supplemented by a system of electric control from a pendulum clock, which is itself incapable of being re-acted upon by the uniform motion clock.

For all ordinary observing, and even for micrometric work, clocks of the class *a* are made, which answer admirably, but for photographic equatorials I believe it will be found necessary to employ clocks of the *b* type, and for this reason: the tendency of the compensation in uncontrolled clocks (class *a*) is to correct the *rate* of the clock when from any momentary cause it is disturbed. The best it can do is to bring the *rate* absolutely right again, but it cannot act till an error has actually occurred, and therefore, although the rate is corrected, the *position* of the star on the plate is shifted by the amount of the error. I have heard it stated by the designers of some of these clocks that errors were corrected *before* they existed! It is hardly necessary to stop to show the fallacy of this, but it is evident that the increased or diminished resistance, or friction, or whatever it is, that checks the speed, can only exist from, and in consequence of, the error itself.

In the case of micrometric measures, it is not of very much consequence if a minute error occasionally creeps in, provided the speed keeps constant during the few seconds or minutes required for making the bisections, but in the case of the photographic telescopes, if the image of the star takes up a new position any time during the exposure, it is of course fatal.

Let us try now and get an idea of what amount of accuracy is really necessary for this work. We often hear of a perfect equatorial clock, but the word perfect is, I fear, as loosely used in this connection as in others.

I have heard in days gone by a perfect clock defined as one which drove the instrument so accurately that if you set the telescope on a star and went to dinner you would find the star still in the field when you resumed your observations after dinner. Allowing, say, two hours between the ante-prandial and the post-prandial observations, and assuming the eye-piece to be (as we may fairly do) a low one of about 20′ of arc field, this would mean that the clock did not vary more than 600″ of arc or 40 seconds of time an hour. The accuracy we now require for these photographic telescopes is something very different. The image of a 12th magnitude star impresses itself on the plate, with moderate exposure, in the form of a circular disk of about $\frac{1}{700}$ inch diameter. If the clock vary one-tenth of a second during the exposure, the disk will be elongated by $\frac{1}{1000}$ inch, producing a very sensible distortion.

We must not therefore have any errors over one-tenth of a second, and if possible it should be reduced to one-twentieth.

It will not be necessary that the clock keep within this one-twentieth of a second for more than ten or fifteen minutes, because it is always necessary to watch the image occasionally through the guiding telescope, and correct whenever refraction becomes apparent; but what I do urge as absolutely necessary is that the clock shall go so perfectly as not to require more than the occasional attention of the observer, instead of the constant and never-ceasing watching with ordinary clockwork. No one who has not tried it can imagine the strain required to keep a constant watch on a star image for 30 or 40 minutes, but if attention be only required for a second or so every few minutes there is no difficulty or irksomeness whatever.

Even the most enthusiastic admirers of various forms of equatorial clocks will not venture to assert that they will go for fifteen minutes without one-tenth of a second of error. There is now, however, no difficulty in controlling a uniform motion clock from a pendulum so that it will never vary one-twentieth of a second from it. It may therefore, I think, be assumed that some form of electrical control is necessary. There are, as far as I know, four forms of control to choose from.

First, Dr. Gill's, as applied to the 15-inch equatorial at Dun Echt with admirable success.

In this an electric current is sent once a second from an independent pendulum, which may be any distance away. That current passes through a certain wheel in the clock, with contacts so arranged that if the clock be going exactly with the pendulum the current is sent in a direction which keeps one of two rubbers rubbing on a

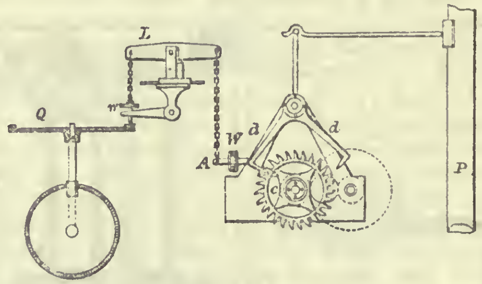


FIG. 1.

quick-moving wheel of the clock. If the clock, however, goes the least quantity too fast, the wheel has revolved a little further than it should at the moment the next current comes from the pendulum, and the current is sent in such a direction as to cause both rubbers to rub on the clock wheel. If, on the contrary, the clock has gone a shade slower, the current is sent in a third direction, which lifts both rubbers off. This control, so far as it goes, acts almost perfectly, but it is open to this objection, that as it only corrects the errors of whatever shaft in the clock the contact-wheel is attached to, any error in wheels between that and the telescope screw are unaffected by it; also I find in practice that when it is attempted to control a clock by alteration of friction, on any heavy quick-moving part, it takes some little time to act, and

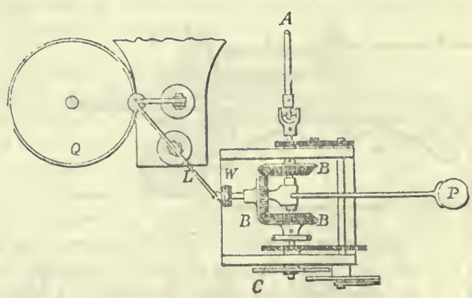


FIG. 2.

then generally overdoes the correction, causing what is generally termed "hunting." The second form of control is the first which I introduced.

Fig. 1 is an elevation, and Fig. 2 a plan, of the arrangement which is attached to the back of the main clockwork, and can be seen in Fig. 3 at E, but on too small a scale for description; A is a portion of one of the uniform clock motion spindles, or any shaft coupled thereto; B, B, B, are the three wheels of an ordinary mitre *remontoire* train driving by weights, W, the scape-wheel, C, into the teeth of which gear the pallets, D D, which pallets are driven by the electric pendulum, P.

The electric pendulum is connected to and driven by a current from any independent clock. To the weight-carrying arm of the *remontoire* is attached a small chain or wire, which communicates any motion it may have to the lever, L, from the other end of which lever hangs a weight, *w*, smaller than W, which weight is therefore raised when the *remontoire* arm is lowered, and lowered when the *remontoire* arm is raised; Q is a disk of metal

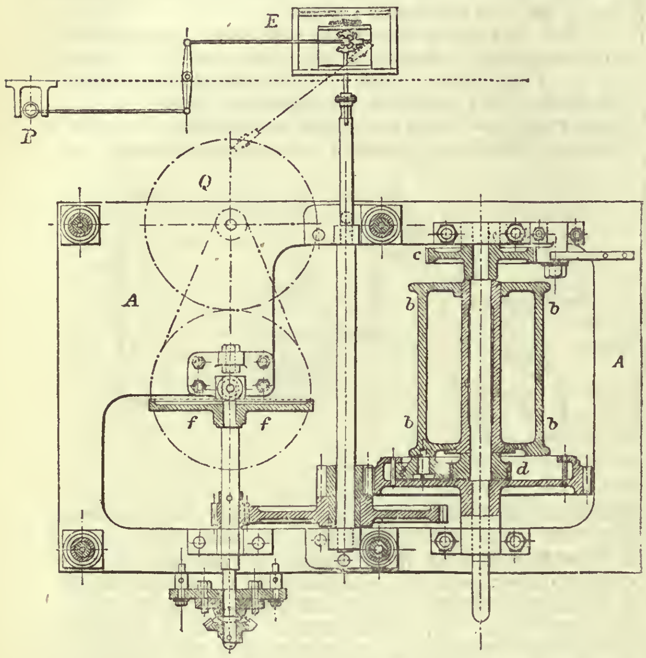


FIG. 3.

on a vertical spindle of a uniform motion clock, and revolving rapidly (say 300 per minute). When the weight, W, is below its mean position, it is in contact with the disk Q, and (the lower end of it being coated with leather) produces a considerable amount of friction, and therefore tends to retard the speed of the clock; when the weight, W,

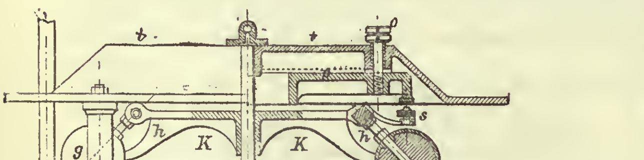


FIG. 4.

is above its mean position, it is altogether out of contact with the disk Q. The action is as follows: Supposing the shaft, A, to be revolving exactly one per minute, the pendulum to be vibrating exactly 60 per minute, and that there are 30 teeth in the scape-wheel, it is evident that the *remontoire* arm, and therefore, the weights, W and *w*, will vibrate backwards and forwards the same distance each second, and that the mean position of all will be the same each second. Under these circumstances, the weight, W, will be alternately 0·5 second in contact with the disk Q, and 0·5 second out of contact, and the uniform motion clock is rated, *per se*, just so much fast, that the resting of the weight, W, for 0·5 second in each second, will bring the rate right.

Now, suppose an error of acceleration to arise in the uniform motion clock, the mean position of *remontoire* arm will rise; therefore W will fall, and, instead of rubbing in contact with Q for 0·5 second, it will rub for 0·6 or 0·7 second, according to the extent of the error. This will tend to check the rate, and this check will continue till the relative position of the uniform motion shaft becomes as it was when the clock was going correctly.

If a retardation occurs, the reverse effect will take place, and the weight, W, will rub only for 0·4 or 0·3 second, instead of 0·5, until the error be corrected.

So far as described, there was no particular novelty, as most of this arrangement, in principle, had been tried before, the failure that had resulted being due to the fact that it was found impossible to prevent the pendulum being influenced by the difference of force on the pallets, under varying circumstances, the pendulum being in the former case driven by the scapement; not by electricity, as in this case.

This difficulty was got rid of by:—

(1) Making the pallets (as they are not required to drive the pendulum) of such form that the teeth of the scape-wheel impinge upon them nearly at the angle of repose.

(2) By driving the pendulum by electric current from another clock, thus virtually rendering the pendulum not a pendulum at all, but a lever worked backward and forward by electricity, and not subject to alteration in its rate by slightly varying force on the pallets.

An arrangement is also attached (but not shown in the figure, to avoid confusion) by which, if either portion of the clock fails to do its duty from want of winding, want of electric current, or other cause, the connection between the two systems is instantly severed, automatically.

(*To be continued.*)

NOTES.

MR. GRIESBACH, of the Geological Survey of India, who has lately been engaged in geological work in Afghanistan, and who was geologist to the Afghan Boundary Commission, has been appointed to Beloochistan, "to carry on geological investigations into the mineral deposits of the country."

AT the meeting of the British Association at Newcastle there will be a joint discussion by Sections B and G of a paper to be read in the latter Section by Sir I. Lowthian Bell, F.R.S., President of Section B, on "Blast Furnace Practice."

THE International Astronomical Congress will hold its sittings in Brussels from the 10th to the 12th inst., and at Liége on the 13th. The attendance from all European countries and America will, it is anticipated, be very large.

IT is reported from Brussels that M. Dutoit, the Transvaal Minister of Public Instruction, is now endeavouring in Belgium and Holland to recruit the necessary staff for organizing a Dutch University in Pretoria, the capital of the Transvaal.

COLONEL THUILLIER'S report on the progress of the Survey of India for the past year shows that the party employed on the trigonometrical surveys has completed the 370 miles remaining of the secondary triangulation along the east coast of India. The secondary triangulation was also carried out for an aggregate length of 270 miles by parties employed in Beloochistan as a basis for topographical surveys in that region. The work of the geodetic party comprised measurement of seven arcs of longitude in Southern India, and the tidal survey party continued its observations with self-registering tide-gauges at several stations along the coast, where tidal observatories are established, and connected with the operations of spirit levelling. Geographical surveys have been carried out vigorously in Upper Burmah, nearly 21,000 square miles having been surveyed and mapped on a half-inch scale. Reconnaissance along the Nepal boundary has supplied a rough basis for a more accurate and detailed survey of the northern frontier when an opportunity offers. Interesting additional information regarding Bhootan and Tibet has been obtained from the adventurous travels of native explorers trained and sent thither by the Department. Of the new maps 4062 were published during the year, and heavy demands continue for trans-frontier maps, and maps of Upper Burmah. The photographic and lithographic offices show the large out-turn of 1,203,861 copies during the year, including high class illustrations for archæological and other reports.

A RECENT mail from New Guinea brings information that the Italian naturalist Signor Lorie had landed in that country, and was proceeding to carry out arrangements for a scheme of scientific investigation which he proposed to himself. His present intention is to remain for several years in New Guinea, where he intends, in addition to following his favourite scientific pursuits, to devote some of his time to exploration work. Signor Lorie is described as a great enthusiast, and a man of determination and courage.

THE *American Meteorological Journal* for August contains an instructive article, by Prof. W. Ferrel, on decrease of temperature with increase of altitude. The author reviews the cases of rapid decrease which would occur were the atmosphere without aqueous vapour and in a stable state; of the very low temperature that would exist a little above the earth, if there were no atmosphere; of the low temperature of the upper atmosphere, owing to radiation into space, if the earth were surrounded by a clear atmosphere, not heated by the solar rays. The very rapid decrease of temperature with height is prevented by the ascending currents, caused by unstable equilibrium, and by the heat of condensation given out after the vapour has ascended to the altitude where condensation commences. The average vertical gradient is less in the cloud region than in the lower strata of the atmosphere, and less in the lower strata in cloudy than in clear weather, as shown by the results of Glaisher's balloon observations. He also refers to the more frequent unstable state of the atmosphere in spring and early summer, owing to the lower strata at that season being warmed up faster than the upper strata; in the fall of the year the unstable state is not so readily produced, and more settled weather prevails. Mr. H. H. Clayton has a paper on diurnal and annual oscillations of the barometer. It is pointed out, in the report of the expedition to Lady Franklin Bay, that if the diurnal pressure at five Arctic stations differing largely in longitude be plotted in simultaneous time, the epochs of maxima and minima show a striking coincidence with each other; the author traces the probable cause of the occurrence of the maxima to the expansion and overflow of air from Asia and America to the Pole; and of the minima at the Pole to the fact that the outflow from the Pole towards those continents is not replaced by an influx in that direction from the oceans. The retardation of the annual maximum from the Arctic region to the Equator, and of the minimum from the southern parts of the continents to the Arctic region, is also attributed to the relative heating and cooling of the continents and oceans. The remaining articles are: on the mineral waters of Gratiot County, Michigan, by Dr. Brainerd, giving an analysis of the waters and the virtues of the substances contained in them; the State tornado charts of Kansas and Indian Territory, by Lieut. Finley; a translation of a paper, by Saussure in 1796, on the use of the sling psychrometer, from which has resulted the modern use of that instrument; and, on atmospheric economy of solar radiation, by A. Searle, with comments by Prof. Ferrel (the principal point is that the earth is kept at a higher temperature than it would be, owing to the fact that heat is transferred upwards by conduction and convection instead of by direct radiation).

THE syllabus for the year 1889–90 of the Manchester Technical School has been issued. It shows the importance and magnitude of the work in which this institution is engaged. There are eight departments in the day and ten in the evening school, beginning with a manual training school for boys, which is the beginning of the whole course. This school is not intended to teach boys a trade, but to provide them with a complete education of both head and hand, in the belief that in this way their powers will best be developed and they themselves be best fitted for after-life. The syllabus this year has some new features. In manual training there is a special course on Saturday mornings for schoolmasters and teachers in the use of wood-working tools, with a view to enable them to introduce manual training among their own pupils. In commercial geography there is to be a special course of lectures of a practical character. Type-writing is another novelty. The chief feature is instruction in the use of the Remington and Caligraph machines. With a view to obtain the necessary skill, each student has three hours' practice per week. There is a special class for women in shorthand, in addition to increased facilities for male students. A special honours class has been formed for evening students in magnetism and electricity, telegraphy, and electric lighting. Especially it should be noted that facilities are offered for a comprehensive study of commercial subjects. There are now great facilities to evening students for the study of science and of art in their application to all the more important industries. The school staff consists of 52 teachers. Last session the school was attended by 3328 individual students.

WE have received the prospectus of the day classes in arts and science and of the evening lectures for the session 1889–90 of the University College, Liverpool.

THE Colonial Board of Viticulture in Melbourne recently proposed the establishment at public expense of an experimental vineyard and school of viticulture for the colony. The suggestion has now been accepted by the Minister of Lands, and a site has been selected for the purpose at Rutherglen. The area selected is 200 acres, and it will be permanently reserved for the purpose. Instruction will be imparted at the institution by capable teachers in the most approved methods of vine cultivation, and experiments will be conducted with the view of testing the value of new plants said to be suitable for growth in Victoria. Funds for conducting the school will be provided in the present year's estimates, but pending the formal vote the Minister has authorized the expenditure of a sum sufficient to at once plant 20 acres of the reserve, and so expedite the work. This will enable the Board of Viticulture to take advantage of the present favourable season.

IN his last Report, the British Vice-Consul at Nisch mentions the terrible havoc which is being made by disafforestation in Servia since its independence. He says that during the Turkish occupation Servia was covered with magnificent forests of oak, beech, chestnut, and walnut trees, by means of which the country was assured of a regular and plentiful supply of water, and in the recesses of which the natives found shelter and refuge from their foreign conquerors. From the date of her independence a destruction of these invaluable treasures commenced which has been carried on with remorseless and unreflecting perseverance, and it appears as though there were at the present day a race against time to complete the havoc. From time to time the consciences of Ministers and Governments have roused them to interfere, but, beyond passing laws which remain a dead letter, hardly anything has been done to arrest the evil. Floods in winter and drought in summer were declared by Mr. Borchgrave, in 1883, to have already begun to exact the penalty which carelessness or want of foresight must be called upon to pay; but the peasant and his goats continue their work of destruction, whilst the authorities are apparently more anxious to avoid occasions of discontent which restrictive measures would create than of applying such remedies as legislation has placed in their hands. Whole mountains may be seen completely denuded of timber, with the exception of a low worthless scrub, which were, a few years ago, covered with woods, but which have fallen victims to the innumerable herds of goats which are allowed to browse at will. The peasants amongst whom the land was divided at the time of the Servian independence have cleared vast tracts for the purposes of agriculture, and possess the right of cutting timber for firewood in those forests which are under the management of the different *communes*. Very little coal is used for household purposes, and the amount of wood required for daily consumption adds enormously to the drain on the national resources. The best-wooded parts of Servia are the districts of the south and south-east, but especially the department of Toplitza, which may be said to contain the only remaining virgin forests of Servia, and whence are annually drawn large supplies of walnut trunks and oak staves for casks. The heights of the Nischava Valley, Stalatz, and Krushevatz furnish excellent building timber. Oak forests are abundant on the Turkish frontier of Vrania. Walnut trees, which attain to an enormous growth, have been mercilessly dealt with, the value of this timber having attracted the attention of Austrian merchants, who send agents to choose and cut the wood for exportation. The fir and juniper are found in the central and western valleys, and on the great Kopavnik Range on the south-east, the pine on the heights of Zlatibor.

HERR TROGNITZ contributes to the last issue of *Petermann's Mitteilungen* the results of calculations which he has made of the areas of the various South American States. These are based on the maps in the latest edition of Stieler's Atlas, which are compiled from the latest official and other information. The figures are in square kilometres.

Brazil	8,361,350
French Guiana	78,900
Dutch ,, ...	129,100
British ,, ...	229,600
Venezuela	1,043,900
Columbia	1,203,100
Ecuador	299,600
Peru	1,137,000
Bolivia	1,334,200
Chili	776,000
Argentine	2,789,400
Uruguay	178,700
Paraguay	253,100
Total	17,813,950

THE *Colonies and India* reports from Tasmania that a movement is on foot in Hobart for the creation of a University. A notice of motion directing attention to the desirability of such a step was given in the Council of Education by the Minister of Education, and the subject was to be considered at a meeting on June 19. "We hope to hear that it has been favourably considered, as the colony is quite prosperous enough to maintain such an institution, and it would be one which would be extremely useful, as well as being to some extent an adornment to the picturesque capital of the Island Colony."

MR. G. W. ROOSEVELT, American Consul at Bordeaux, in a report on the treatment of diseases of vines in France, says that in spite of the numerous inventions meant to destroy Phylloxera, it still continues its ravages. One of the most recent plans is that of an American, Mr. L. H. Davis, who inoculates the vine, through a carefully made excision, with a preparation which he claims is destructive to the Phylloxera, while it leaves the vine uninjured. It is too soon yet to speak of the results of this plan. Dr. Griffin advocates a distribution by a machine constructed by him of a substance which can be used in either a dry or a liquid state. Last spring he operated on a vineyard placed at his disposal by the French Government, and had the satisfaction of seeing the vines treated by him sound and healthy, while other plants in the same vineyard were perishing. The most generally employed remedy has been found to be very serviceable, and free from the danger that was thought to follow it—that is, the submersion for not less than forty days in carbon of sulphur dissolved in water. In light permeable soils a strong mixture is used, but on hard soils a weaker solution is better. Within the past few years the actual area of the vines destroyed by this pest is 1,200,000 hectares, or, roughly speaking, one-half of the vineyards of France; and if we remember that a hectare of vines is worth about 6000 francs we can see what a terrible loss France has suffered. In the case of Oïdium, as in that of Phylloxera, no positive remedy has yet been discovered, but the usual mode—that is, the application of sulphur, pure or mixed—checks the disease, and at the same time helps the growth of the vine. In fact, so great have been the good results of the use of sulphur, that it will for the future be used in most vineyards, even where Oïdium does not exist. Till the year 1885 no remedy was known for mildew. Since that year, however, salts of copper have been successfully employed, though there is some doubt whether that substance is really beneficial to the vineyards. The most general method is to pluck off the diseased leaves and burn them. Besides these there are other methods, such as the use of *bouillie bordelaise*, *eau céleste*, ammoniate of copper, and verdigris with powdered sulphate of copper. On account of the recent appearance of the disease called black rot, no satisfactory remedy has yet been tried. With regard to anthracnose, if steps are taken early in the spring, the disease may be brought under control. Perhaps the best remedy is a mixture of lime and sulphur. A first sulphuring is given when the shoots are four or five inches long; then, if lesions appear, the operation is repeated in about a fortnight with a mixture of lime and sulphur, the proportion being one part of sulphur to three of lime. A mixture of plaster and sulphate of iron has also been very successful. The only really efficacious remedy for pourridie is by removing and burning all roots showing traces of the disease. Erinnose may be treated like mildew—that is, by repeated applications of sulphur.

A REPORT on the appearance of the Hessian fly in this country, by Mr. Charles Whitehead, the Agricultural Adviser, has been issued by the Agricultural Department of the Privy Council. The fly was first seen in 1886 in Great Britain, and in that year did some harm to wheat and barley plants in England and Scotland. In 1887 it was noticed in twenty counties in England and ten in Scotland, wheat and barley crops being considerably damaged by its action. The weather during the summer of 1887 was hot and dry, like that which normally prevails in America, and was presumably favourable to the development and progress of the fly. During 1888, when the summer was unusually wet and cold, very little was heard or seen of the Hessian fly either in England or Scotland. But during the early months of the present year the temperature was high and the rainfall small, and from the reports received by the Agricultural Department the infested area has largely increased in England. In Scotland it does not appear to have made so much progress. Still it is present in many Scotch counties. The actual amount of injury to the crops is slight, and, so far as can be ascertained, is not in any instance so important as that caused in some cases in 1887. It is most probable that the injurious operations of the insect have been checked by the wet, cold weather which has followed the abnormal heat of May, and the warmth and dryness of June. When a cycle of hot summers occurs, it may happen that the ravages of the Hessian fly may be general and calamitous. Mr. Whitehead therefore urges the desirability of careful watching and the prompt adoption of simple methods, which he describes, for preventing the increase of the pest.

THE *Industrie Textile* has a long account of the treatment of wild silks (that is, those which are furnished by silkworms other than those of the domesticated *Bombyx mori*) in their native countries. In India there are no less than fifty varieties of silk-bearing insects, the most important of which is called tussur, that is, "the weaver's shuttle." The caterpillar, like the moth, is of a great size, and feeds upon more than thirty species of plants. The cocoons of the tussur, which make their appearance twice in the year, are found attached to the branches of trees in the jungle in large oval masses. The caterpillar lives from thirty to forty days, and then weaves its cocoon. In four or six weeks from this time the moth comes out and lays eggs from which comes a second generation of caterpillar. These wrap themselves in the cocoon, and remain hanging to the trees throughout the rainy season—that is, for seven or eight months. The cocoon, which is about four times the size of that of the mulberry silkworm, is composed of a double and interrupted thread of about 1400 metres in length. The thread is impregnated with uric acid of sodium, which must be removed by the aid of an alkaline wash before the thread is unwound. The tussur is tended with great care; in fact, for centuries various religious usages have been employed in rearing it. The moth, which is a large insect of a brownish colour, having its wings beautified by four transparent eyes, is venerated, and may be only approached by people of a certain caste. Unlike the tussur, which has been domesticated in India for some thousands of years, the cocoons of the other species are collected in the jungle. Amongst these is the *Attacus cynthea*, which feeds on the castor-oil plant, and of which the cocoon is white. Other species are the *Antheræa assama* and the *Cricula trifenestra*, which lives on the mangrove tree and spins a cocoon of a bright golden colour. The most important Chinese species is the *Antheræa pernyi*, which is cultivated in the province of Sze-chuan. In China also is found the most beautiful of all moths, the *Attacus altas*, which spins an enormous cocoon, covered at both ends with a very thick silk, known as Fagara silk. In Japan are the *Ailanthus* caterpillar, and the *Yamanai*, which till lately was reserved for the exclusive use of the Mikado, and the exportation of the eggs was an offence punishable with death. At present attempts are being made to cultivate this species in France, and it is believed they will be successful.

MESSRS. BLACKIE AND SON will publish immediately a translation of the well-known "Organische Chemie" of Prof. Bernthsen, of Heidelberg. The translation is by Dr. George McGowan, University College, Bangor, and the original text has been specially brought up to date for this edition by the author, who has throughout shown keen practical interest in the perfecting of the English edition.

THE Royal Meteorological Institute at Utrecht has just published a valuable atlas of twenty-two charts, containing the results of observations in the Indian Ocean, for the separate months of December, January, and February. Some portions of the ocean are naturally without data, but the amount of material dealt with may be judged of from the fact that 51,799 observations have been used in the construction of the wind chart for December. The temperature of the sea-surface is represented by isotherms drawn for every 2° C., and shows in certain regions, *e.g.* near the Cape of Good Hope, considerable differences of temperature in the various months. The currents are plotted in 1° squares, in two colours, showing the resultants of the currents setting towards the west and of those towards the east, separately, together with the number of observations from which they are calculated. Atmospheric pressure is represented by isobars drawn for every 2·5 mm. They show an area of high pressure between lat. 30° and 35° S. and long. 80° and 90° E.; in January there are two centres of high pressure, at long. 55° and 85°. The temperature of the air is exhibited by isotherms for every 2° C. The difference between the air and sea temperature is generally small, but the excess of the latter sometimes amounts to 5° C. The wind is represented by roses showing the relative frequency for direction (only), arranged according to homogeneous areas, combining the same prevalent winds in irregular spaces. Other charts show specific gravity, rain, percentages of storms, and other interesting information.

THE third session of the Edinburgh University Extension Summer Vacation Course was held, as before, during August, at Granton Marine Station, through the kindness of Dr. Murray, Director of the *Challenger* Expedition, and of Mr. Irvine, of Royston. The courses of botany and zoology were conducted, as last year, by Prof. Geddes and Mr. G. A. Thomson. This year each course was divided into an elementary and an advanced section, the former dealing with Vertebrates and Phanerogams, the latter with Invertebrates and Cryptogams. Prof. Geddes also delivered a course of twenty lectures on sociology. Some twenty-five or thirty students attended. All the courses were supplemented by demonstrations in the field and on the shore, and by visits to public and private gardens and to the Museum.

IN the abstract of Dr. Stefan's paper on "Ice Growth" (NATURE, August 22, p. 400), the third paragraph should read as follows:—"The theory gives for the thickness (h) of ice formed in the time (t) the following formula, which is approximately correct—

$$h^2\left(1 + \frac{cf}{3\lambda}\right) = \frac{2k\mathrm{T}}{\lambda\sigma}.$$

In this formula (c) is the specific and (λ) the latent heat of ice; (k) is the coefficient of conduction, (σ) is specific gravity, (f) is the temperature at the surface of the ice at the time (t), (T) the sum of cold for the same time; the last is the sum of the temperatures counted downwards from 28° F., or the freezing-point of sea-water, from the commencement of ice formation up to the time (t)."

THE additions to the Zoological Society's Gardens during the past week include a Common Peafowl (*Pavo cristatus* ♂, white variety) from India, presented by Mr. Richard Hunter; a Manx Shearwater (*Puffinus anglorum*) from Essex, presented by Mr. J. M. Wood, C.E.; a Lesser Razor-billed Curassow (*Mitua tomentosa*) from Guiana, presented by Mr. G. H. Hawtayne, C.M.Z.S.; a Louisianian Meadow Starling (*Sturnella ludoviciana* ♀) from North America, presented by Mr. Newton Hayley; a Turtle Dove (*Turtur communis*), European, presented by Mr. C. W. Cousins; five Herring Gulls (*Larus argentatus*), British, presented by Sir Richard Nicholson.

OUR ASTRONOMICAL COLUMN.

YALE COLLEGE OBSERVATORY.—The report of this Observatory for the year ending June 1889 has recently appeared. Mr. Brown, the Secretary, records the carrying out of several improvements in the grounds of the Observatory, and the continuation of the work of the Thermometric Bureau, 7475 thermometers having been received for verification during the year. Dr. Elkin, the astronomer in charge of the heliometer, completed the measures for the triangulation of the region near the North Pole during the summer of 1888, and the necessary reductions are well advanced. In October 1888 a series of observations for the parallax of Iris was commenced in connection with similar series to be effected at the Cape and at Leipzig, but measures were only obtained on thirty-four instead of sixty-five nights. In addition to these, however, 168 sets, each consisting of sixteen pointings, were obtained by Messrs. Elkin and Hall, for the diurnal parallax of the same planet. The discussion of the whole series of measures has been undertaken by the Yale astronomers, and the work has already been commenced. A series of measures for the parallaxes of Victoria and Sappho are now being undertaken, and it is expected that two additional observatories, those of Bamberg and Göttingen, will co-operate in the work. The heliometer has also been employed in further researches on stellar parallax; Procyon and Altair having been taken up by Mr. Hall, Vega and Regulus by Dr. Elkin. During the winter Mr. Hall completed the reductions of his work on the orbit of Titan; whilst Dr. Elkin took part in the observation of the total solar eclipse of January 1, 1889, which he observed from Winnemucca, Nevada, under very favourable circumstances.

NEW MINOR PLANET.—A new minor planet, No. 287, was discovered by Prof. Peters at the Clinton Observatory, on August 25.

Should the two planets discovered on August 3 both be confirmed as new bodies, that discovered by M. Charlois will be No. 285, whilst Herr Palisa's will be No. 286; the former having been discovered at 10h. 46m. G.M.T., and the latter at 11h. 27m.

COMET 1889 *d* (BROOKS, JULY 6.)—Dr. K. Zelbr has found elliptic elements for this comet, with a period of 12⅓ years. The ephemeris from these elements compares as follows with Herr Knopf's ephemeris which is given below:—

Zelbr-Knopf.

1889.	R.A. m. s.	Decl. ′
Sept. 8	−2 17	+1·7
Oct. 2	−5 49	+5·1

Herr Knopf's Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
Sept. 8	0 5 14	5 43·8 S.	0·3709	0·1333	1·34
12	0 3 51	5 39·0	0·3734	0·1353	1·31
16	0 2 21	5 34·0	0·3759	0·1386	1·28
20	0 0 48	5 28·6	0·3786	0·1430	1·25
24	23 59 15	5 22·4	0·3814	0·1487	1·21
28	23 57 47	5 15·3	0·3843	0·1554	1·16
Oct. 2	23 56 26	5 7·0 S.	0·3873	0·1632	1·09

The brightness on July 8 is taken as unity.

COMETS 1888 *e* (BARNARD, SEPTEMBER 2) AND 1889 *b* (BARNARD, MARCH 31).—The following ephemerides are in continuation of those given in NATURE for 1889 August 1:—

1889.	*Comet* 1888 *e.* R.A. h. m. s.	Decl. ° ′	*Comet* 1889 *b.* R.A. h. m. s.	Decl. ° ′
Sept. 7	18 32 7	8 46·3 S.	4 25 52	2 13·1 N.
11	18 27 51	9 9·2	4 17 53	1 1·8 N.
15	18 24 14	9 30·3	4 8 52	0 15·0 S.
19	18 21 15	9 49·8	3 58 47	1 37·1
23	18 18 47	10 7·8	3 47 36	3 3·9
27	18 16 50	10 24·4	3 35 21	4 34·5
Oct. 1	18 15 19	10 39·7 S.	3 22 1	6 7·4 S.

REDUCTION OF RUTHERFURD'S PHOTOGRAPHS OF THE PLEIADES AND PRÆSEPE.—Two papers by Dr. B. A. Gould have recently been published in the memoirs of the National Academy of Sciences, which possess a very special interest at the present time, for they show that in the very dawn of astronomical photography, it was possible to determine the relative places of the members of a star-cluster from a series of photographs with a precision comparable to that attained even with a heliometer. In 1865, Rutherfurd had obtained a number of photographs of the Pleiades, and early in 1866 he placed the results of his measurements of these plates in the hands of Dr. B. A. Gould, who deduced from them the R.A.'s and Decls. of nearly fifty stars of the group, and who, further, compared these results with the heliometer measures of Bessel, made more than a quarter of a century earlier. The comparison, even as it stood, was a most satisfactory one, for, in spite of imperfections in the method of measuring the photographs, such as naturally occurred in a first essay, the probable error of a measure, either of distance or position, appeared as small for the photograph as for the heliometer, and the general agreement of the two methods was most gratifying. The paper in which this discussion was given, though presented to the Academy on August 11, 1865, has only recently appeared—a regrettable delay, for it might well have been that so striking a demonstration of the possibilities of the photographic method might have insured its adoption by astronomers a decade, or even two, earlier than has actually been the case. Dr. Elkin has now (*Astron. Jour.* No. 197) compared Dr. Gould's places of the Pleiades with values interpolated between the Königsberg heliometer places for 1840, and the Yale places for 1885, and after clearing the photographic results for some systematic errors thus disclosed, he finds the residuals very small indeed. Of sixty-eight values, only one exceeds 0″·38, and forty-seven are less than 0″·20, nor do they show any systematic character depending on distance or direction from the centre of the field. The probable error of a co-ordinate from the photographic measurements, he deduces as:—

For the brighter stars, ± 0″·079,
,, fainter ,, ± 0″·101.

Dr. Elkin concludes, therefore, that "the smallness of these probable errors must be convincing proof that in photography we have really a means of investigation for micrometric work at least on a par with any existing methods as regards magnitude, and doubtless far surpassing them in ease of measurement and output of work."

The paper on Rutherfurd's photographs of the Præsepe was presented to the Academy on April 14, 1870, and the central star to which the others were referred being a small one, instead, as in the Pleiades, of a very bright one, which had been, therefore, always much over-exposed, the results were even more satisfactory.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 SEPTEMBER 8–14.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 8

Sun rises, 5h. 26m.; souths, 11h. 57m. 27·9s.; daily decrease of southing, 20·6s.; sets, 18h. 29m.: right asc. on meridian, 11h. 8·4m.; decl. 5° 32′ N. Sidereal Time at Sunset, 17h. 41m.

Moon (Full on September 9, 13h.) rises, 18h. 37m.; souths, 23h. 35m.; sets, 4h. 44m.*: right asc. on meridian, 22h. 47·7m.; decl. 12° 20′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	7 43	13 22	19 1	12 33·5	4 47 S.
Venus ...	1 49	9 30	17 11	8 40·3	18 5 N.
Mars ...	2 56	10 23	17 50	9 33·7	15 45 N.
Jupiter ...	14 50	18 43	22 36	17 54·6	23 27 S.
Saturn ...	3 32	10 47	18 2	9 57·4	13 44 N.
Uranus...	8 38	14 4	19 30	13 15·3	7 20 S.
Neptune..	21 12*	5 2	12 52	4 11·7	19 26 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Sept.	h.	
10	19	Mercury at greatest distance from the Sun.

Meteor-Showers.

	R.A. °	Decl. °	
Near ξ Persei	60	37 N.	Swift; streaks.
,, Aldebaran	72	14 N.	,, ,,
,, Vega	282	42 N.	Swift; bright.
	354	38 N.	Very swift.

Variable Stars.

Star.	R.A. h.	m.	Decl. °	′				h.	m.	
Algol	3	1·0 ...	40	32	N. ...	Sept.	14,	2	3	*m*
W Tauri	4	21·7 ...	15	51	N. ...	,,	11,			*m*
X Boötis	14	18·9 ...	16	49	N. ...	,,	10,			*m*
U Coronæ	15	13·7 ...	32	3	N. ...	,,	9,	23	43	*m*
U Ophiuchi... ...	17	10·9 ...	1	20	N. ...	,,	8,	1	33	*m*
			and at intervals of					20	8	
X Sagittarii... ...	17	40·6 ..	27	47	S. ...	Sept.	9,	1	0	*M*
W Sagittarii ...	17	57·9 ...	29	35	S. ...	,,	14,	23	0	*m*
U Aquilæ	19	23·4 ...	7	16	S. ...	,,	12,	3	0	*m*
η Aquilæ	19	46·8 ...	0	43	N. ...	,,	8,	1	0	*M*
X Cygni	20	39·1 ...	35	11	N. ...	,,	8,	21	0	*M*
T Vulpeculæ ...	20	46·8 ...	27	50	N. ...	,,	9,	21	0	*M*
R Vulpeculæ ...	20	59·5 ...	23	23	N. ...	,,	11,			*M*
δ Cephei	22	25·1 ...	57	51	N. ...	,,	10,	22	0	*M*

M signifies maximum; *m* minimum.

GEOGRAPHICAL NOTES.

FROM advices just received from Queensland the *Colonies and India* understands that Sir William MacGregor left Port Moresby, for the ascent of Mount Owen Stanley, on April 19, in an open boat, with a party of fourteen for Vanapa River, 30 miles westward. He arrived safely, and pushed the boat up river for eight days, during which period he encountered many difficulties in crossing rapids and dragging the boat over rocks. When he could get no further he camped on the left bank of the river and sent Mr. Cameron (his secretary) back to Port Moresby for supplies, with native carriers to cross the mountain. Mr. Cameron returned with two boats loaded with provisions, thirty natives, and six Polynesians. All being ready, on May 17 the party, comprising forty-two men, left the camp, all packing, and the Governor taking the heaviest load. There were only four whites in the party. They crossed Mount Gleason at Eyton Junction, and then shaped a course north-east by east. At a height of 175 feet they crossed Mount Gunbar, next Mount Kulwald. Mount Belford was crossed at the Joseph River, after which they descended to the Goodwin Spur, and saw the first native house at Goodwin's village, Mount Musgrave, where they camped, the Governor going ahead with four Polynesians and seven natives; then ascended Mount Musgrave for over 7000 feet to Vanapa River and Mount Knutsford Range, over rough country; they followed a spur leading west. After three days' march they descended the spur, and began the ascent of Mount Owen Stanley on June 9, reaching the top on June 11 and 12, returning to Mount Musgrave on June 16. All hands started homewards and arrived at River Camp on June 22. They left on June 23, visited a mountain village on June 24, and met the steam launch from the *Merrie England*, which was searching for the Governor's party, and took them in tow. They arrived at Mana Mana on the 25th, and were taken on to Port Moresby, where the party landed after two months, all well. The only death that occurred was that of a native. The country traversed was very mountainous, and no table-land was discovered. Of the geological formation the country is mainly decomposed slate, granite, and quartz, with no sign of gold. Specimens of rock were collected by the Governor. The climate to 8000 feet is moist, above that dry and bracing. Natives were met on only two occasions, and were extremely friendly. They were stout well-built men, but no women were ever seen. Cultivation paddocks were fenced in. Potatoes, yams, and sugar-cane were plentiful, as also was tobacco. Natives, who were devoid of warlike implements, paid particular attention to head-dresses made of shells procured from the natives on the eastern coast of German New Guinea, who were showing friendly communication. Across the Owen Stanley Range the Governor collected many specimens of new plants, among others being some beautiful yellow rhododendrons, which he has since sent to Melbourne to Baron Von Mueller for report. A great number of new grasses in large patches were discovered. At Mount Victoria (Goodwin) he secured several new birds and one animal, which was something like a native bear, but had a long tail and dusty-brown collar and black extremities. The extreme length was 3 feet 6 inches, of which the tail was 1 foot 6 inches. There were five claws on all the feet, the tail was bushy, and it was estimated that the weight of the animal was 40 pounds. The birds of the lower altitudes were the same as those before seen, except as to a new paradise bird similar to the Great Epimachus. Sir William procured a female *Astrachia stephania*, the only male bird of that species being in the Museum, Berlin. The Governor procured several new small birds at Mount Victoria, including the identical English lark. Unfortunately, they were eaten by the Polynesians. Entomological specimens were obtained, including a milk butterfly. Only a few were captured.

ACCORDING to a *Times* telegram from Zanzibar, the Sultan has signed a concession to the British East Africa Company, of Lamu and the Ben-Adir coast, embracing all his territory from Kipini to Mruti. The concession embraces the administration and government of the island and port of Lamu, and of the northern mainland ports of Kismayu, Brava, Magadisho, and Warsheikh. The company's jurisdiction is thereby extended from the River Umba, in the south, to the port of Warsheikh in the north, an extent of about 700 miles of coast-line. Lamu is, next to Zanzibar and Mombasa, the most important port on the East African coast, and commands the trade of the mainland south of Kismayu, and that of the fine waterway of the Tana. It has been for years past the seat of a flourishing commerce, which is mostly in the hands of British Indian subjects, and it is a port of call for the British India Company's steamers.

OUR SENSATIONS OF MOTION.[1]

WE may distinguish two quite different kinds of sensation of motion, active and passive. When we walk or run or row, we use our muscles, and this use of our muscles is the cause of our motion, and also the cause of special sensations which may in a sense be called active sensations of motion. But we have other sensations than these connected with motion. For, if we are carried, or rocked in a boat, or dropped from a height, we are not only moved, but we are conscious of a very well marked sensation which we may call a passive sensation of motion. When we move ourselves we feel both kinds, and it is difficult for us to analyze what we feel and distinguish between our sensations as movers and our sensations as moved. It is to our passive sensations of motion that I wish to direct your attention to-night, and as these can best be examined in cases where they are not complicated with the other kind, we shall confine our attention almost exclusively to passive motion—that is, to cases wh.re we are moved without any exertion of our own muscles. Now the first thing I have to say is in at all events apparent contradiction to the title of this lecture: it is that we have no direct sensation of motion as such. That this is so will be at once obvious if we consider the fact known to all, that we are at this moment being moved with very great velocity through space. We know that this is so, astronomers can prove it, but we are so perfectly unconscious of it that I dare say most of us here could not point the direction in which we are moving; in fact, as we are ignorant of the direction and rate of motion of the great system of which our solar system is a part, no one can say how fast and towards what point in space we are travelling. What we are conscious of is change of motion. It is because the motion of the earth is so steady, because, although very rapid, its changes are very slow, that we do not feel it.

There are two altogether different ways in which a body can be moved. These have been called respectively translatory and rotational. In translatory motion the body is always similarly oriented. Thus, if we consider motion within so small a part of the earth's surface that we may neglect the earth's curvature, such an object as this desk is subjected to purely translatory motion if we move it thus, so that the same side always looks up, and the same side always looks east. Rotational motion involves a change of orientation, and is rotation about an axis. This axis may always be the same, or it may change, and the change of axis may be abrupt or may be continuous. Most of the motions which we observe are made up of both kinds. When we travel by rail—always supposing that we sit still in the carriage—we are subjected to a purely translatory motion only when the train is running along a perfectly straight piece of the line. When it goes round a curve, we are—always supposing we sit still—subjected to rotation as well as to translation; because our face no longer continues to look in the same direction, but, as long as the train is running on the curve, continuously changes the direction in which it looks.

Let us examine what we feel when we are passively subjected to purely translatory motion. As long as the motion is steady,

[1] Armitstead Lecture delivered in Dundee, by Prof. A. Crum Brown.

unchanged in speed or in direction, we feel nothing, as has been pointed out already. Let us look at the case when the speed changes, the direction remaining the same. We have to consider separately three different directions: (1) horizontal, (2) up, and (3) down, because we shall see that our sensations are different in these three cases. With change of speed in horizontal motion we are all familiar. The starting and the stopping of a train or of a steamer give us ample means of studying it. We all know the jolt of a badly started train. What we feel in such a case is, mainly at all events, due to our body being jerked forward or backward, according as we are sitting with our back or our face to the engine. But if the train is carefully started we find that our rate of motion may in a very short time be changed from nothing (relatively to the earth) to, say, thirty or forty miles an hour, without our feeling anything but the up and down rattle due to the slight unevenness of the rails. And the same was the case till comparatively lately with stopping. Now, however, since the introduction of the continuous brake, a train can be so rapidly stopped—its rate of motion, that is our rate of motion when we are in it, can be so very quickly changed from, say, sixty miles an hour, to nothing—that we do feel a strange, not altogether pleasant sensation. Experience has taught us what that sensation means, but at first it was so novel that experience was necessary to interpret it. It is not a sensation of jolt, the change though rapid is not abrupt. What we really feel, although it takes some amount of careful observation and some thought to see this clearly, is that the direction of the vertical, the direction in which a body falls, the direction in which our body presses has been changed. We feel this most distinctly if we are standing when the brake is applied; we feel that if we do not take means to prevent it, we shall fall over, and we prevent this by bringing our body into the line of the new vertical. Our feeling of unsteadiness depends on our uncertainty how long the new state of matters is to last. It lasts as long as the speed is being changed at the same rate, and the deviation of the new from the real vertical depends on the rate at which the speed is being changed. Our perception of deviation from the vertical is pretty acute. Most of us can tell a line to be off the vertical when it is inclined only a few degrees to it. In ordinary cases we have extraneous help in judging. We have walls or chimneys, known to be vertical, or surfaces known to be level, with which to compare, but even when we have no assistance of this kind we are not often far wrong. It might be supposed that it is the pressure of our body on the floor or ground that gives us the idea of the vertical, but that idea still exists in cases where we can feel no such pressure. If our body is supported in water, or entirely submerged, as in diving, we still have a very distinct, and fairly accurate notion of up and down, although in such cases, as our body is very nearly of the same density as water, the resultant pressure on it is small. We shall see in a little a possible explanation of our sense of the vertical. When the train in which we are travelling runs quickly round a sharp curve, we feel something very like the sensation just described. And indeed it is due to a perfectly similar cause; the apparent vertical is the direction of the resultant of the force of gravity and the centrifugal force, and is, as every engineer knows, more inclined to the real vertical as the curve is sharper and the speed of the train greater. In this case the sensation is complicated, because the motion is not one purely of translation, but, as already pointed out, is compounded of translatory and rotational motion.

Let us now look at cases of up and down motion. As we can study horizontal motion in the railway train, so we can up and down motion in a lift. Here also we see that it is change of motion which we really perceive. For, once the lift is started, and is moving smoothly and uniformly, either up or down, we are quite unconscious of the motion. It is the start and the stop, or the quickening or slowing of the motion only that we feel. And the stopping of the upward motion produces exactly the same feeling as the starting of the downward motion, provided they are equally smooth and free from jerk. It is easy to see what are the physical conditions here. Just as the acceleration in a horizontal direction inclines the apparent direction of gravity, so acceleration up increases, and acceleration downwards diminishes, the apparent intensity of gravity. If the lift *fell* down, unrestrained, its inmates, during the short time the experiment would last, would have no sense of the force of gravity at all. An object dropped from the hand would not fall down to the floor, because the floor itself would be falling at the very same rate as the object. And what is true in this extreme case is true also in a measure in all cases of downward acceleration. But only in cases of *acceleration*, for, however fast the lift goes down, if it moves uniformly, without change of speed, the bodies of those in it press on its floor exactly as if it were at rest. Similarly, upward acceleration increases the apparent force of gravity. The physical conditions, then, of our perception of acceleration of translatory motion in any direction are change in the apparent direction, intensity, or both, of the force of gravity. It is a strange and interesting fact that our perception of downward acceleration—that is, of diminished force of gravity—is more acute than that of acceleration upward or in a horizontal direction. We feel the starting of the lift as it goes down, and its stoppage when it has come up, much more distinctly than the start on the way up or the stop at the end of the journey down. And when we are rocked in a rolling steamer, it is the beginning of the downward move that is most perceived.

Having now discussed the phenomena of our sensations connected with translatory motion, let us examine what our experience is when we are turned round, or subjected to rotational motion. We execute such movements every minute of our waking life. But as with translational motion, so, and even more, with rotational motion, it is impossible to analyze our sensations when they are complicated with what we feel we do. And in the case of rotation a very serious complication is introduced by our seeing how we are being moved. So that, to make a strict examination of our sensations in this matter, the observer must place himself blind-folded on the rotating apparatus, and be passively turned round. Or, as in Prof. Mach's very ingenious experiments, a small hut with translucent paper windows may be placed on the turn-table for the reception of the observer. Just as we can move, or be moved, right or left, backwards or forwards, up or down, so we can be spun round about a fore-and-aft, a right-and-left, or an up-and-down axis, and about each of these axes either the one or the other way round. It is plain, however, that we can get simple results only in the case of rotation about a vertical axis, because otherwise a great complication would be introduced by the varying position of our body relatively to the direction of gravity. We shall see that we can get everything we require with rotation about a vertical axis. Here we find, as in the former case, that it is only change of motion that is perceived. The observer sits on a chair on the turn-table, his eyes are bandaged, and an assistant gives the table a steady, uniform rotation. At first the observer feels the turning quite distinctly, but after less than a whole revolution the sensation becomes very indistinct, and, while the turning still continues at the same rate, soon disappears altogether. If the rate of turning is now increased, he feels it begin again, all that he perceives being the increase; his perception of that also soon dies away, so that in a short time he may be spinning rapidly round, while he feels completely at rest, and is only aware that he has been gently turned round a little, two or three times. But if you now stop him he feels a turning round in the opposite way to that in which he really was turning, the fancied rate of turning being, at the moment of stopping, that of the real turning which has just been stopped. This imaginary rotation dies away, exactly as the sensation of the real rotation did. Now, *very nearly* the same thing takes place, whatever is the position in which the head is placed during the experiment, *if the head is kept rigidly in the same position during the whole of the experiment.* Let us look at a case in which the position of the head is not kept the same during the experiment. The observer sits on the table, with his head inclined to one side, so that the line from ear to ear is vertical. He is now turned uniformly round; as before, he feels the turning at first, but as the uniform turning goes on the sensation dies away. When he feels perfectly at rest, let him give the word to stop, and at the same instant raise his head into the ordinary position. He will now feel as if he were being turned about the line from ear to ear—that is, now, about a horizontal axis. If his right ear was down when he was actually being rotated, and if the turning was with the hands of a watch lying with its face up, then the imaginary rotation will be the opposite way round—he will feel as if his head were going forward and his feet back. This sensation will last only a short time, but there is a risk in trying the experiment, that the observer may try to correct this alarming overturn by throwing himself backwards; if he is nervous it may therefore be as well to have him strapped to the chair. Whatever line in the head we make vertical while the real rotation is going on—that is, whatever line in the head we make the axis of the real rotation—that line is the axis of the apparent rotation which we feel when the real rotation stops, however we may move our head at the time of the stoppage. There is a practical joke depending on this principle, which I have seen played. The subject of the joke, who ought, of course, to be a person not conversant with the laws of the sensation of motion, is asked to hold a poker upright on the floor, and, placing his forehead on the top of it, to walk three times round it, rise up, and walk across the room. His march round the poker is a rotation about the fore-and-aft axis of his head; when he rises up he feels the contrary imaginary rotation, about the same axis, now, of course, horizontal, so that, if he went round with the sun, he falls to the right, and to the left if he went round the other way. In a very interesting experiment with the turn-table we have a combination of real and apparent rotation. Lie down on the table, say on the left side, so that the left ear is vertically under the right ear, so making the right-and-left axis of the head the axis of rotation; let the table be turned round at a uniform rate, wait until all sensation of rotation has ceased, and then, while the uniform turning is still going on, roll yourself over on your back. You will then experience a very startling sensation. The new axis of rotation of the head is the fore-and-aft one; there was no rotation about it before, therefore you feel that real rotation, the real rotation about the old axis—right-and-left—has just ceased, therefore you feel the imaginary opposite rotation. The sudden occurrence of the combination of these motions, felt as real, resulting from a cause so seemingly inadequate, rolling from your side to your back, gives rise to an almost dreadful sense of insecurity.

Thus then in rotational as in translational motion it is change of motion, what is technically called acceleration, which we perceive. There are two questions which naturally arise in this connection: (1) What is the use of this sense? and (2) What is the organ of this sense, and how does it work? What is the use of it? Everyone will, I am sure, admit that it must be of great use to us to have a constant knowledge of the direction of the vertical; to have, as it were, a private level of our own, which we cannot mislay. As to our sense of rotation, it is to it chiefly that we owe what we call our knowledge of the airts; it enables us, as we walk about on winding roads, or through narrow crooked streets, to retain some idea of the real directions. But the chief use, no doubt, of the sense of rotation is to enable us to control and regulate the rotatory movements of our head—movements we are constantly making as we look about us. It may be asked, in these short quick movements of the head, where is the secondary sensation of turning the other way which I described? We never experience it at all. Mach has very clearly, and with great penetration, explained how this comes about. These quick movements, our habitual movements of rotation, are so short in their duration, that during them we do not come to feel that our head is at rest. The sense of the original real rotation is still vivid when the rotation is stopped, so that the secondary sensation of an imaginary motion the other way round merely annuls the primary sensation, puts an end to it when the real rotation stops. Without such a stopper of sensation we should go on feeling the rotation for a short time after it was done.

What is the organ of this sense? There is in our head a very remarkable organ which has been for long a puzzle to physiologists, an organ which is found not only in our heads, but also in the heads of all mammals, of all birds, and of all but the very lowest fishes (and even in the very lowest fishes it occurs in a less developed form). This organ is so closely related in position to the organ of hearing, that it was long supposed to be a part of it, and we shall see what attempts were made to explain it as an organ of hearing. I shall give as short a description of it as is compatible with making it plain how it can act as the organ of the sense we have been considering. I must at the same time confess that in some points our knowledge of the matter is still imperfect, and that much has still to be done before we can explain its action as fully as we can that of the eye, for instance.

The organ in question is lodged in a bony cavity continuous with that which contains the organ of hearing, and for this reason was long, and perhaps by some is still, regarded as itself having something to do with the perception of sound. This cavity in the hardest bone in our head consists of four parts—the vestibule, and the three semicircular canals. The vestibule is an irregular chamber, in man about $\frac{1}{5}$ of an inch long and $\frac{1}{7}$ of an inch broad and deep. In its walls are five openings leading to the semicircular canals. These are tunnels in the bone having an elliptical or circular section, and opening at each end into the vestibule. The central line of each canal lies nearly in one plane, which we may call the plane of the canal. At one end of each canal there is an enlargement called the ampulla. The planes of the three canals are approximately at right angles to one another. The canals are named from their position—the horizontal, the superior, and the posterior; the two latter unite at their non-ampullary ends before joining the vestibule, so that there are five and not six openings into the vestibule from the canals—three ampullary, one for each canal, and two non-ampullary, one for the horizontal, and one common to the superior and the posterior canals. The plane of the horizontal canal is nearly horizontal in the ordinary position of the head in all animals, and is therefore at right angles to the mesial plane: the planes of the two other canals make nearly equal angles with the mesial plane.

In the bony labyrinth just described there is inclosed a membranous labyrinth of a generally similar form. It consists of the utricle, lodged in the vestibule, and of three membranous canals, each furnished with a membranous ampulla. The membranous labyrinth does not fit tight into its bony case. The utricle is much smaller than the vestibule, which contains, besides, the saccule, an organ connected with the cochlea; and the diameter of the membranous canals, except at the ampullæ, is much less than that of the bony canals. The membranous ampullæ, on the other hand, nearly fill the bony ampullæ. The entire cavity is thus divided into two spaces, one within, the other around, the membranous labyrinth; each is filled with a liquid, the endolymph and the perilymph. The nerves are distributed to one spot in the utricle, and to a crescent-shaped ridge near the middle of each ampulla. The nerves end in hair-cells, the hairs of which project into the endolymph. The *macula acustica*, the spot in the utricle to which nerves are distributed, is covered with a gelatinous layer in which are embedded small crystals of carbonate of lime.

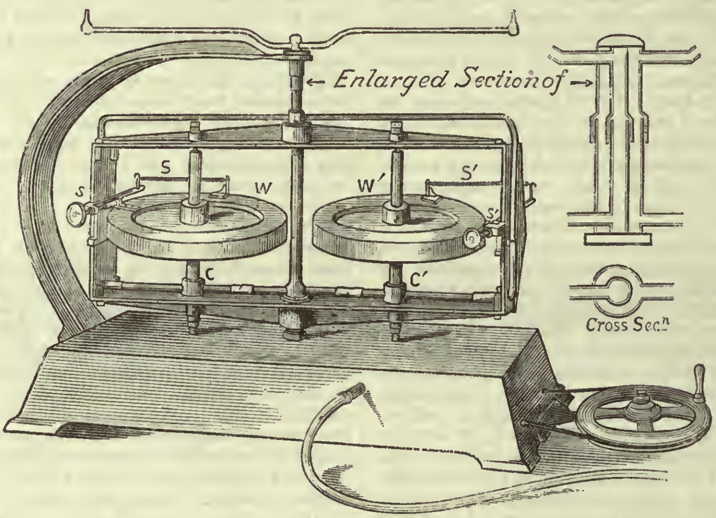
Everyone must see that an apparatus so purpose-like in its arrangement must have a use, and this use must be one applicable to all the higher animals.

It was long supposed that it had to do with our perception of the direction from which sounds come to us. The idea is not unnatural, and is obviously derived from the nearness of the apparatus to the organ of hearing, and from the relation of its form to the three dimensions of space. No explanation has ever been given how it could serve this purpose; and we can easily show that it does not do so by experimentally showing that we have no means of ascertaining the direction from which a sound comes except by two or more simultaneous or successive observations. If a sound is heard louder in the right ear than in the left we conclude that it comes from the right, and by turning round the head we soon get a sufficient number of observations to enable us to judge of the exact direction. If a short sharp noise is made at a point equidistant from the two ears, we do *not* know the direction from which it comes unless we see what causes it.

But the apparatus is admirably fitted to act as the organ of the sense of rotation, or rather of the sense of acceleration of rotatory motion. Let us first consider the action of one canal. If the head is rotated about a line at right angles to the plane of the canal, with the ampulla leading, you will see from looking at the diagram that there will be a tendency of the endolymph to go from the utricle into the ampulla, and of perilymph to go from the space between the bony and the membranous canals into the utricle. These will conspire to stretch the membranous ampulla where the nerve-endings are, and we can easily see how this will stimulate the nerves, and send a message to the brain. But this stretching will not take place if the head be rotated the other way about. In that case the tendency of the fluids will be in the opposite directions, and will rather make the ampulla less tightly stretched, and we can readily suppose that this may not stimulate the nerves, and no message will be sent to the brain. One canal will thus be able to give indications of rotation about one axis, in one of the two ways round. But for each axis we have two canals, one turned the one way and the other the other. And as by means of three rectangular axes we can represent any rotation, so any rotation will be perfectly recognized by means of the six canals. That this is actually the function of this organ is further proved by the effects of injury or disease. One ear is sometimes attacked by inflammation while the other ear is unaffected. In such cases the patient suffers from persistent vertigo—that is, sense of rotation where no real rotation occurs. This is, at least, one form of what is known as Ménière's disease, so-called from the name of the physician who first drew the attention of medical men to it. Now it is obvious that, if the six canals act in the way I have indicated, the pathological irritation of the three canals of one ear will produce a sensation of rotation about an axis the position of which we can foretell from the relative positions of the planes of these three canals. And clinical observations on persons suffering from this disease show that the vertigo actually is about this axis. Deaf-mutes are persons who from a very early age have had no sense of hearing at all. This condition may arise from the imperfect development of the organ of hearing, or from its early destruction by disease. In either case it often happens that the organs we have been discussing, from their nearness to the organ of hearing, are involved in the mischief, and are also imperfectly developed, or destroyed by disease. Deaf-mutes have therefore not unfrequently the semicircular canals in a state unfit for use. Experiments have been made on deaf-mutes with the object of testing the accuracy of their sense of rotation. Those who have made these experiments report that many deaf-mutes are insensitive to rotation. If these observations are confirmed, the theory I have just been explaining will receive a very great support.

In order to illustrate this theory, and to show that the principle on which it is based is a sound one, I have devised a sort of working model which I shall now show you. I may say that when I accepted your invitation to lecture here, and had selected the subject of our sensations of motion, the idea occurred to me of making a sort of working model of the semicircular canals. The difficulty was to find an instrument-maker who could help me over the obstacles which always lie in the way of a designer who is not himself an engineer. I take this opportunity of thanking Mr. Alex. Frazer for his help in this matter. He at once understood what I wanted, and so gave me the use of his skill and experience that the instrument here is exactly what I intended it to be, and a great deal better than my most sanguine hopes.

The model, as perhaps you will better see from this somewhat diagrammatic drawing than from the machine itself, consists essentially of two heavy wheels, placed side by side, with their axes parallel, in a frame which itself can be turned round about an axis parallel to that of the wheels. These heavy wheels correspond to two parallel canals, say the two horizontal canals. As it is the inertia of the fluid in the canals which enables them to work, so here it is the inertia of the heavy wheels. Each wheel has a stop, which altogether prevents its turning, in one way round, beyond a certain point. The one wheel is thus checked in turning the one way, the other in turning the other way. Each wheel is just held against its stop by a spring which is stretched when the wheel turns away from the stop. Each wheel with its stop and spring is as nearly the mirror image of the other as it could be made. When I turn round the frame, both wheels tend to lag behind the rotation of the frame, on account of their inertia. One of them cannot lag behind at all because of its stop, and the other cannot lag much behind because of its spring; the stronger we make the spring the less can it lag behind. This lagging behind is, of course, a turning of the wheel on its axis, relatively to the frame, in the opposite sense to that in which the frame is turned. As we continue to turn the frame with uniform speed, the spring brings the wheel back to its original place against the stop, and further rotation at the



same rate makes no change in the relative position of the parts of the machine. But if we now quickly bring the frame to rest, both wheels in virtue of their inertia tend to continue their rotation: one, that one which made the relative movement before, cannot continue its rotation because of its stop; the other can rotate a little, not much, because of its spring—it turns a little, but is soon brought back to its original position against its stop by the spring. You will easily see that just as in the model the inertia of the wheel corresponds to the inertia of the fluid, so here the stretching of the spring corresponds to the stretching of the ampulla. All that we want to make the model complete is to find some way of making the stretching of the spring visible, something which shall correspond to the message sent to the brain. You cannot easily see the stretching of the spring while the frame is turning round, and it was necessary to devise some way of making it visible. We must here leave the analogy of the living organ. The brain turns with the labyrinth, but we are the brain of this machine, and we do not turn with it. After a good deal of consideration, and after thinking of and rejecting a good many plans, I fell upon the one I shall now show you. In the lower end of the axle of each wheel there is fixed a stop-cock, through which gas can pass from one pipe to another. When the wheel is against the stop only a very little gas passes—just enough to prevent the jet going out. When the wheel turns away from its stop, the stop-cock is opened, and the stop-cock is so adjusted that the quantity of gas passing shall be roughly in proportion to the stretching of the spring. By a contrivance indicated in the diagram, the two gas pipes, one from each stop-cock, are brought through the axle of the frame and led each to a gas jet.

Now, when I begin to turn the frame one jet flares up, but as I continue the turning, as nearly uniformly as I can, you see the jets remain at their minimum, which I shall call zero of sensation. Of course I could have made this zero the zero of gas too, but then we should have needed a subsidiary flame to light the gas when the stop-cock opened. I now stop the frame, and you see the other jet flare up for a little. That corresponds to the secondary imaginary rotation which we feel when a real rotation is stopped. I ought to apologize for so often calling this a secondary or imaginary rotation. I hope you all see now that it is as really an *acceleration* in the strict meaning of the word as the original start from rest.

I have taken this question—What is the organ by means of which we perceive acceleration of *rotatory* motion?—first, because it has been most fully worked out. We now come to the question, How do we perceive acceleration of translatory motion? This, as we have seen, is the same as the question, How do we by our senses recognize the direction and estimate the intensity of what is to us at the moment the force of gravity? A very natural suggestion as to the way in which we perceive the intensity of this force is that it is a skin sensation; that it is by the greater or less pressure which we feel on that part of our body which rests on our support. Prof. Mach, to whose experiments I have had often to refer, and to whom we owe, more than to any other investigator, our knowledge of the whole subject of the sensation of motion, has very clearly proved that this is not the case. Everything we know as to this sense leads us to look for its organ in the head. And there is an organ which, to some extent, at all events, seems to be what we are in search of. The *macula acustica* in the utricle is a spot well furnished with nerves, and we have not found out any special function for it. There is a similar *macula* in the saccule, that other membranous bag contained in the vestibule. Mach has suggested that the *macula* of the utricle may be the organ by means of which we perceive acceleration of translatory motion. Let us look at it, and see how far it is fitted to act as a level. Its length is stated by Prof. Schwalbe to be about $\frac{1}{8}$ of an inch, and its breadth a little less. According to the same observer, it covers a part of the floor, the anterior wall, and a part of the external wall of that part of the utricle called the "recess." Its nerves end, as has already been stated, in hair-cells, and these are covered by a gelatinous substance filled with a fine powder of crystals of carbonate of lime. What is interesting to us in this description is that it looks in three directions, and that the whole of it is covered with a powder of considerably greater density than the fluid (the endolymph) with which the utricle is filled.

Let us try to imagine a model of this structure. Let us take a box of glass, so that we may see what goes on in the inside of it. Let us put on a part of the bottom of the box, on the end of it, and on a part of the side of it, a layer of thin jelly mixed with fine sand. Fill up the box with water, and put on a lid. We shall find that we have an apparatus that does to some extent answer the purpose of a level. When we change its inclination, the jelly but for the sand would indeed have very little tendency to change its position, but the sand, being specifically heavier than the water will, and will either move through the jelly if that is thin enough, or pull the jelly with it. In any case, a change of position of the box will involve a change in the relative position of its contents. In the actual case of the *macula acustica* such a change in the relative position of the sand and the hair-cells must give rise to an irritation of the terminations of the nerves, and send a message to the brain. We cannot as yet work out all this in detail, as we can the way in which the canals give us information as to the acceleration of rotational motion, but we know enough to turn our attention to the subject; and we may hope that, by more accurate study of the sensation phenomena, and by comparison of them with the anatomical facts, this important and interesting physiological question may be satisfactorily answered.

ON THE GEOLOGICAL HISTORY OF THE PREHISTORIC FLORA OF SWEDEN.

FIFTY years have passed since the Danish Professor, Japetus Steenstrup, presented to the world his masterly researches on the history of Denmark's peat-bogs. These researches clearly demonstrated that the forests of Denmark had suffered remarkable variations. The oldest forests had consisted chiefly of aspen (*Populus tremula*), next, for a long period, of Scotch fir (*Pinus sylvestris*), then of oak, and, finally, of alder (*Alnus glutinosa*). Remains of the beech—now Denmark's chief species of tree—are, however, entirely absent from the peat-bog. Consequently, it must have been the last to immigrate. It was a natural surmise—and one even advanced by Steenstrup—that the changes referred to were connected with a gradual softening of the climate, a view defended, too, by Prof. Forchhammer.

But Steenstrup's researches were in advance of their time; glacial geology was only in its infancy, and voices were therefore raised both in Denmark and Sweden claiming to interpret these changes in the forest vegetation as one of Nature's great systems of evolution, whereby one variety, so to speak, prepared the soil for the next comer, without any reference to climate. However, this view has now but an historical interest. For, since our knowledge of the geology of the Glacial age has become more and more enlarged, and since remains have been found in Scania of a true Arctic flora embedded in the fresh-water clay deposits of that province, a return to Steenstrup's theory that the changes of climate and forest vegetation were related was but natural. Indeed, the same Arctic flora was shortly discovered underneath the aspen layer in the Danish peat-bogs, so that the aspen flora cannot be regarded as the first after the Glacial age. By degrees, as the ice melted, the denuded soil was invaded by the Arctic flora from the south. First, when the climate became still milder, and a forest vegetation could flourish, the aspen and the birch immigrated, and in turn the pine, oak, and alder. Each one formed in its day the forest of Denmark, and they were naturally accompanied each by its own peculiar undergrowth of shrubs and plants. Enormous ages elapsed between these events. The remains of the peat-bogs show that generations upon generations of grand firs flourished before the oak immigrated and before the pine flora was at last ousted. And in its turn the oak reigned supreme during countless ages, until that, too, was extinguished by the alder and the beech. During the fir period, the men of the Stone Age spread themselves over the land; when the fir was supplanted by the oak, the Bronze Age began. If we bear in mind how exceedingly slow the extension of the oak and the beech is, we can form some idea of the immense time that must have elapsed since the Ice age.

Therefore the flora of Denmark consists entirely of the offspring of immigrated plants. Many of the species which appeared in the country did not remain; to them Denmark was only a station on the road towards higher latitudes. This was, for instance, the case with the greater portion of the Arctic flora, as well as with the fir. From the beginning of the historical period the beech has flourished throughout the whole country.

In Sweden, in districts rich in calcareous matter, tuff strata are deposited from springs which, by their contents of carbonic acid, contain carbonate of lime. When calcareous water is exposed to the air, the carbonic acid gas evaporates, and the carbonate of lime is precipitated in the form of a white deposit, which soon hardens to stone. Such a deposit is therefore particularly natural around the mouth of a spring or in some pool into which the calcareous water is discharged. Consequently the leaves or other remains of plants growing around are covered, soon after falling into the water, with a thin coating of chalk, and although they are by degrees destroyed, this imprint in the chalk remains—often so distinctly that the finest fibres of a leaf may be traced.

A necessity for the formation of calcareous tuff is therefore the presence of calcareous rocks, whence the water may draw the lime. And, indeed, with us all calcareous tuff deposits, as far as we know, are confined to where the chalk formations are richest, as, for instance, Scania, Western and Eastern Gothia, Jemtland, Ångermanland, and Åsele Lappmark.

The greatest in extent and richest in leaf imprints are the old well-known tuff strata at Benestad, in Scania, north of the town of Ystad. They were formerly largely worked for building purposes, as, for instance, for several churches. The tuff is referred to by early writers as rich in leaf imprints, but in their writings a serious error crept in, viz. that even leaves of the beech were imprinted. This is wholly without foundation.

In consequence of the quantity of stone removed, it is now impossible to fix precisely the nature of the stratification, and what we know on this point is due to the particulars supplied by Baron Claes Kurck, who carefully examined the strata. His researches fully confirm the views of the writer, expressed as far back as 1872, viz. that the oldest strata were deposited whilst the aspen was the predominating tree in the districts, and before the fir had immigrated. Kurck has also found here traces of birch, grey sallow (*Salix cinerea*), and possibly the common sallow (*Salix caprea*). Above this stratum we come to the fir, deposited when that predominated. The imprints of the fir, in the shape of needles, branches, bark, and cones, show that this tree grew close by the springs. Most of the tuff dates from the fir period, but during the same age other species of trees gradually immigrated, of which indications are found in the lower parts of the fir deposit. From these the National Museum possess a rich collection, chiefly made by Nordenskiöld in 1873. It contains several rare species of plants, and the imprints of leaves are so remarkably clear that the collection is one of the greatest ornaments of the palæontological section.

Of the trees which flourished contemporaneously with the fir, we learn from Kurck that the birch, mountain ash (*Sorbus aucuporia*), *Salix caprea*, and *Salix aurita*, were the oldest, and the hazel but little younger. To somewhat later strata he refers dog-wood (*Cornus sanguinea*) and berry alder (*Rhamnus frangula*), and he believes that the remains found of Dutch rush (*Equisetum hyemale*), and the guelder rose (*Viburnum opulus*) also date from the same period. If this be the case, it is probable that some leaves in the Nordenskiöld collection of hawthorn (perhaps *Cratægus monogyna*) also belong to this stratum.

Naturally, the species named also appear in this collection. The later strata from the fir period are, according to Kurck, distinguished by a quantity of leaves of the mountain elm (*Ulmus montana*). Leaves of hazel, birch, aspen, &c., are also found; whilst, for the first time, leaves of the lime (*Tilia parvifolia*) are met with, but very rarely. In this stratum Kurck has also found the common bracken (*Pteris aquilina*) and meadow-sweet (*Spiræa ulmaria*). Some leaves of the alder he believes to be still younger.

Besides the species named—which are all found with remains of the fir—are some others. Already in Nordenskiöld's collection notice was attracted to portions of a stratum in which the fir was absent, and which in a measure differs in appearance somewhat from the rest of the tuff. These portions contain leaves of the mountain ash, the common oak (*Quercus pedunculata*), viz. hazel, lime, salix, and birch. This stratum has been re-discovered by Kurck, and is, as might be expected, younger than those named. It may be added that, according to earlier writers, leaves of the maple (*Acer platanoides*) have also been found at Benestad, but latterly none have been discovered.

It would seem, then, that there is at Benestad a counterpart to the Danish aspen, fir, and oak periods; but we cannot quite say that as regards the second period. There is, for instance, nothing to prevent the fir having vegetated, through some accidental causes, at Benestad, even during a part of the oak period. This is the more likely as we find the tree at the present day in Northern Scania. If, therefore, on the one hand, it is certain that the elder pine strata at Benestad belong to the true fir period—the time before the immigration of the oak—it cannot, on the other, be denied that the younger section of the fir strata may have been deposited already when the oak immigrated thither. That some of the fir-bearing strata must have been deposited relatively late seems evident from the presence of such plants as dogwood, hawthorn, elm, &c. However, the problem will no doubt be finally solved when once the peat-bogs of the province have been palæontologically examined.

Of the beeches and hornbeams (*Carpinus betulus*), now common in the district, there are no traces in the strata, and although the springs still yield plenty of water, there appears to be no deposit of calcareous tuff whatever. Thus, all we are really able to say respecting the palæontological remains in the fir period at Benestad is that these plants immigrated before the beech, and, most probably, even before the oak, and that all of them came from the south-west.

Respecting the flora which flourished in Scania previous to the aspen and fir periods, we know its characteristics through the vegetable remains in the fresh-water clays of the province. They display a rich Arctic flora, comprising *Dryas octopetala*, *Salix polaris*, *herbacea*, *reticulata*, *Betula nana*, *Oxyria digyna*, &c. An animal fossil must also be mentioned, only recently found among them, viz. *Apus glacialis*, now common in Spitzbergen lakes, but which in Scandinavia is not found south of the lakes in the Dovre Mountains.

In proportion as the inland ice melted, the Arctic flora, so rich in varieties, advanced, but as the climate became milder this flora was replaced by the forest vegetation immigrating from the south, and, at all events at Benestad, the trees followed each other in the same succession as in Denmark, viz. aspen, fir, oak, whilst the beech immigrated considerably later. It is most probable that the forest vegetation followed in the same order in the whole of Southern Sweden, but we do not know this with certainty. For we still know too little respecting the remains of plants in the peat-bogs of Southern Sweden. That we are far behind in this respect is chiefly due to the circumstance that in Denmark the peat-bogs are turned largely to profitable account.

Of the calcareous tuff strata in the province of West Gothia we know unfortunately very little. They are, however, small in extent, and contain only remains of trees still found in the neighbourhood, viz. hazel, salix, and aspen. Near the Eskedal railway station there is certainly a very large deposit, but not formed of continuous tuff, but of loose calcareous *débris*, which does not retain imprints.

In East Gothia we have two calcareous formations, one near Vreta cloister, which appears to be of a rather recent date, as it contains salix, hazel, oak, and lime. The other, north of Vadstena, is, however, much older, and therefore of great interest. This contains, among other remains of a pure Alpine plant, *Dryas octopetala* (L.), which we already know from the Scania fossil glacial flora, besides dwarf birch (*Betula nana*), and perhaps also *Betula intermedia*. There are also leaves of several varieties of willow, birch (*Betula odorata*), crowberry (*Empetrum*), *Vaccinium uliginosum*, and fir needles. The discovery of Dryas in this locality is of the highest interest and importance, as it leads us to hope that we may discover in other parts of Sweden between Scania and Jemtland remains of an Arctic flora, which, judging from the discovery referred to, must, at all events partly, have advanced from the south through the whole country. Formerly we did not possess a single palæontological proof from this part of Sweden in support of this assumption. The discovery is also of great interest in another respect, inasmuch as it shows that Lake Vettern must have become separated from the Baltic, with which it was once connected, at a time when the climate was Arctic—an assumption in full accord with Prof. S. Lovén's discoveries respecting the Arctic Sea fauna that to the present day is found at great depths in this lake.

The Jemtland strata have of late been examined by Herr A. F. Carlson. This province is rather rich in calcareous tuff deposits, some twenty localities having already been discovered. Here, too, the first forests appear to have consisted of aspen, birch, chiefly *Betula odorata*, and fir, of which latter remains have been found in several places. In four localities *Dryas octopetala* have been found, and in two *Salix reticulata*, both of the Arctic flora. As the former were found at Fillsta and Digernäs, in Sunne parish, and the other at Semla, in Mörsils parish, it would appear to be proved that the Alpine flora of Jemtland formerly had a far greater extension within the province than at present, and that at that period it reached as far as the basin of Lake Storsjö. Without doubt an examination of the fresh-water clays of the province would go to show that the Alpine flora formerly covered the whole of Jemtland. The tuff strata which contain such remains were deposited a little later, whilst the Alpine flora was in process of being displaced by the forest vegetation.

The remaining plants that have been found in Jemtland are Dutch rush (*Equisetum hyemale*), salix, several varieties of willow, dwarf birch, *Betula intermedia* and *alpestris*, *Alnus incana*, crowberry, mountain ash, *Sorbus aucuporia*, *Vaccinium uliginosum*, and sea buckthorn (*Hippophaë rhamnoides*).

From the province of Ångermanland we know two tuff deposits, near each other, but the palæontological remains are few and badly preserved. Here have hitherto been found only some lichen, fir, birch, salix, and willow.

In Åsele, Lappmark, between Långfors and Långsile, there are two deposits—as far as we know the northernmost in Sweden. Both are rich in leaf imprints, and thanks to Colonel N. Sjöberg, of Åsele, the National Museum has obtained specimens. The species are certainly not numerous, but they are well preserved, and consist of lichen, leaves of fir, birch, aspen, salix, some willows, and *Hippophaë rhamnoides*.

As I have already stated, leaves of this plant have also been found in a spot in Jemtland situated more than 1500 feet above sea-level. Here the leaves are found in common with remains of Dryas, but whilst the latter now has to be sought high up in the mountains, the former is, on the contrary, only found by the coast. It is found along the shores of the Baltic, from Roslagen (near Stockholm) to Vesterbotten in the north, and the thorny shrub, with its whitish silvery leaves, and yellow or chrome-coloured sour berry-like fruit, here goes by the name of *haf-thorn* (*i.e.* sea thorn). In other parts of Central and Northern Europe where this shrub grows, it is also a coast plant, but it is found beside the glacial rivers of the Alps; and its former existence in the localities named in Norrland—right in the heart of the country, high above the sea, together with other Arctic plants—shows indisputably that here also it was originally an Arctic plant. But whilst *Dryas*, *Salix reticulata*, &c., were forced northwards by the immigrating forest flora, this plant, on the contrary, found a place of refuge on the sea-shore, where it flourishes to the present day. It seems, indeed, hardly credible that two plants now so widely separated, geographically, as Dryas in the high mountains and Hippophaë by the Baltic shore, once grew side by side in the heart of the country.

Having dealt with the proofs respecting the former extension of the Swedish flora furnished by the palæontological remains of the calcareous tuff strata, I purpose to touch upon an equally important point, viz. that the spruce immigrated comparatively late. In no single tuff deposit has trace been found of this tree, and this circumstance is too uniform throughout to be a matter of accident. Especially peculiar are the conditions in

Jemtland, where several of the localities in which the palæontological discoveries were made are surrounded by spruce forests, and where the tree grows higher up on the mountains than the fir, which is the reverse of what is generally the case. In Jemtland, therefore, the spruce clearly immigrated after the fir, and first when the principal tuff formation had ceased. Whence did the spruce immigrate into Sweden? It cannot have been from the south or from Denmark, for remains of the tree are totally absent in that country's well-explored peat-bogs, neither does it belong to Denmark's present wild flora. Neither can the spruce have come from the British Isles. Certainly it appears from palæontological evidence that the spruce existed in England before the Ice age, but it appears to have been extinguished during that age, as it is absent from the post-glacial deposits as well as from the British flora of the present day. Finally, the scarcity of the spruce in the western parts of South-Eastern Norway fully proves that it did not immigrate from the west. There cannot, therefore, be the slightest doubt that the spruce immigrated into Sweden from the east. This assumption corresponds entirely with the present extension of the tree east of the Baltic. But this immigration cannot have taken place *viâ* Northern Sweden around the Gulf of Bothnia, as this part can be supposed to have had only at a later period a climate mild enough for its existence. It is more probable that the immigration took place *viâ* the Island of Gothland on the south-east coast, or *viâ* the Aland Islands, off Central Sweden, and that the spruce afterwards spread north, west, and southwards.

It may be mentioned, by the way, that the spruce existed in the neighbourhood of Enköping at the time when Lake Mälaren was a bay of the Baltic, and the sea covered the spot where the town is now situated. Of great importance with regard to this point is the discovery recently made by Dr. H. Munthe, that the spruce was found in Gothland at a time so far remote that the division of land and sea then was wholly different from that which at present exists. This seems to speak for the immigration of the spruce by this road. Further, Dr. R. Hult, of Helsingfors, last summer discovered in West Nyland, in Finland, sub-fossil remains of spruce in a stratum which he estimates to be older than the remains of spruce found in Scandinavia, and he therefore considers that the spruce immigrated from Finland.

Considering the present and past extension of the spruce in Europe, one might be inclined to assume that the true home of this tree was Scandinavia, whence it was driven in the Glacial age, but this, it is now being demonstrated, was not the case.

Now, the spruce, in spite of its relatively late immigation, has in Sweden spread greatly, forming huge forests; and we might be disposed to conclude that in its turn it would extinguish other species. Experience from our forests goes to prove that this is really the case. Thus, from Southern Sweden we know from the researches of Dr. R. Hult in Blekinge that the spruce (except in dry localities) generally extinguishes the fir. And reports by Herr C. G. Holmerz and Herr Th. Örtenblad show that this is also the case in Norrbotten, where "the spruce in all more favoured localities wedges itself in between firs and birches, and finally exterminates its predecessors in occupation." Even the oak is ousted by the spruce. Prof. Elias Fries states that "the spread of our noblest foliage tree is being arrested in recent times. In a primæval spruce forest, where there is no more oak in the locality, I have found below an immense layer of moss oak trunks of such dimensions that I doubt whether there are their equal in all Sweden." In Blekinge also similar facts have been brought to light, and recently Prof. F. R. Kjellman expressed the opinion that "the oak flora formerly had a greater extension in our country, but has been thrust aside by the spruce."

Although the spruce is victorious over some species, it is unable to conquer the beech. Therefore there is little chance that the spruce will take possession of our southern counties.

In conclusion, as the result of the known palæontological facts respecting the immigration of our flora, we are able to express the opinion that the greatest part of the Arctic flora, as the inland ice melted, immigrated from the south; and that, of the various forest trees, the birch, aspen, and fir came by the same road, forming the country's oldest forests. From the south, too, we must assume that salix, mountain ash, mountain elm, hazel, lime, with accompanying shrubs, certain willows, guelder rose, *Rhamnus frangula*, *Cornus sanguinea*, and the hawthorn came, and from the same quarter, at a later period, the common ash, oak, and ivy. Furthermore, later still, the beech and the hornbeam, with accompanying shrubs, came from this quarter. The spruce and the beech both immigrated late, but the former from the east. These two forest trees are at present, in different localities, the two most favoured, the beech in the south, and the spruce in all other parts as far as the northern limit of coniferous trees. But the contest between the different species of trees is no longer undisturbed. For since man settled in the land a new factor has arisen, and this factor participates both directly and indirectly in the contest. Originally slight, his influence has grown greater and greater, and the time may come when he will be the arbiter as to the trees that are to form the forests of the future.

A. G. NATHORST.
Geological Survey of Sweden.

AGRICULTURAL EXPERIMENTAL STATIONS IN THE UNITED STATES.

THE following interesting information in reference to the establishment of agricultural experimental stations in the United States is given in a memorandum recently issued by the Agricultural Department of the Privy Council, and laid before Parliament. An "Office of Experiment Stations" has been instituted as a special branch of the United States Department of Agriculture. For the expense in connection therewith a sum of £2000 was voted by Congress in 1888, to enable the Commissioner of Agriculture to carry out Section 3 of the Act of Congress of March 1887, by which experimental stations were established. This said section provides that, "in order to secure, as far as practicable, uniformity of methods and results in the work of the said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important; and in general to furnish such advice and assistance as will best promote the purposes of this Act. It shall be the duty of each such station annually, on or before February 1, to make to the Governor of the State or Territory in which it is located, a full and detailed report of its operation, including a statement of receipts and expenditure to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States." In 1888 an Act was passed by Congress making an appropriation for the Department of Agriculture for the fiscal year ending June 30, 1889, and for other purposes, appropriating £119,000, including the £2000 specially reserved for the Commission of Agriculture, for the purpose of endowing and assisting agricultural and experimental stations throughout the country. Besides this sum, the several States have contributed £25,000, making a total sum of £144,000 given from public funds for the support of these stations. There are now forty-six of these stations in the United States, so that, taking an average, each station will receive over £3000 this year. It is said, however, that several of these stations have sub-stations under them, and that there are 370 trained men connected with the stations in the prosecution of scientific and practical agricultural experiments. The first agricultural experiment station in America was established in 1875 in Connecticut, and the next in California in the year following. In 1879 the well-known Cornell University Station was founded, which has done so much good work, and the equally valuable Wisconsin Station in 1883. No less than twenty-six stations were founded last year, in consequence of the inducements set forth by the Act of 1887. In a recent Report as to the organization of these experimental stations, a list of the staff of each is given, from which list a few examples may be taken to show the extent of work that is performed, or may be performed. At the Connecticut Agricultural Station there is a director who is a Master of Arts, a vice-director who is a Doctor of Philosophy, and a chemist. There are three other chemists who are Doctors or Bachelors of Philosophy, a mycologist, and a practical farmer in charge of grounds and buildings. The staff of the Dakota Station is still more extensive, consisting of a director, a superintendent of the farm, a superintendent of forestry and horticultural experiments, an entomologist, an analytical chemist, a veterinarian, an accountant and stenographer, and a librarian. Upon the staff of the Iowa Station there are two chemists, one for ordinary and one for special work, a botanist for ordinary and special work, an entomologist, a veterinarian, a horticulturist, and a practical farmer. The Cornell University Station staff comprises a chemist, veterinarian, botanist, and arboriculturist, a horticulturist, an entomologist, a cryptogamic botanist, besides an assistant in entomology, chemistry, veterinary science, and horticulture. Among the operations of these agricultural experiment stations are "fertilizer control," or the analyses of manures, the analyses of fodder and feeding-stuffs drainage experiments, feeding experiments with farm animals, observations on milk, the determination of injurious insects, with remedies against their attacks, fruit culture experiments, drinking-water analyses, ensilage experiments, meteorology, seed-testing, analyses of soils and rocks, the culture of various plants for fodder and corn, with other useful work.

SOCIETIES AND ACADEMIES.

Paris.

Academy of Sciences, August 26.—M. Des Cloizeaux, President, in the chair.—On the molecular tactics of the artificial macle of Iceland spar produced by Baumhauer by means of a knife, by Sir William Thomson. The substance of this paper has already been communicated to the Royal Society of Edinburgh, and will shortly be published, under the title of "Molecular Tactics of Crystals," in the Proceedings of the Society. The author also contributes a paper on the equilibrium of atoms, and the elasticity of solids in Boscovich's theory of matter.—Note on the orbits of shooting-stars, and on stationary radiant points, by M. F. Tisserand. A calculation of the elements (mostly parabolic) of their several orbits leads to the inference that the meteoric showers encountered by the earth at different times of the year do not all emanate from the same radiating centre, but belong to different systems proceeding from quite independent radiant points. A series of essays based on the assumption that the orbits are not parabolic, but elliptic, lead to the same conclusion.—On the relations of atmospheric nitrogen to vegetable soil, by M. Th. Schlœsing. This is a reply to M. Berthelot's recent strictures on the author's negative results. These results are here maintained, and M. Schlœsing again argues on fresh grounds that there is no fixation of nitrogen by vegetable humus except through the actual process of vegetation.—Pathogenic properties of the microbes present in malignant tumours, by M. Verneuil. The author still adheres to the opinion already enunciated in 1883, that these parasites have nothing to do with the initial stage of boils, ulcers, cancer, and the like. At the same time he does not regard their presence as a matter of indifference, but admits that in certain cases they may themselves possess special pathogenic properties, in virtue of which they act on the system like septic poisons.—On the progress of the zoological station at Roscoff, by M. de Lacaze-Duthiers. The author speaks in satisfactory terms of the present condition of this station, and of the complementary establishment at Banyuls, which have now been placed in connection with the Sorbonne. The electric light, introduced at Roscoff by the aid of private munificence, is now in perfect working order.—The Eiffel Tower struck by lightning, by M. Mascart. A correct account is given of this occurrence, which took place on August 19, and exaggerated reports of which appeared in the daily papers. The conductor was struck, with the normal results, showing perfect communication with earth, and consequently complete safety of the structure from any danger on this score.—Observations with the pendulum effected in Russia, by General Steibnitski. The author reports that the Russian Imperial Geographical Society is now in possession of three Repsold pendulums, with which the latitude and longitude of Karmakul in Novaya Zemlya and Archangel, the two northernmost stations in European Russia, have been accurately determined.—Occultation of Jupiter by the moon, August 7, 1889, by M. Ch. André. The results are given of the three observations taken at the Observatory of Lyons by MM. André, Le Cadet, and Marchand. None of the satellites disappeared instantaneously, as is the case with stars of the same magnitude (seventh). The disappearance of satellites III., II., and IV. occupied $1''\cdot5$, $1''\cdot1$, and $0''\cdot5$ respectively, giving for their several diameters $0''\cdot46$, $0''\cdot30$, and $0''\cdot15$.—On the angle of polarization of the moon, by M. J. J. Landerer. A method is described by means of which this element has been determined at $33° 17'$, a mean value resulting from eleven series of observations with probable error $\pm 7'$. The same process is equally applicable to the planet Venus.—On the solar spots, by M. G. Spoerer. Besides some brilliant protuberances, the large spot visible from June 16 to 18 was observed on the last day at 10.43 a.m. at Potsdam. But a photograph of the same taken a few minutes before the observation shows no trace of the spot, which is replaced by an even depression on the solar rim, exactly where the spot had been observed. An explanation is suggested of this phenomenon.—Specific heat of aqueous vapour under constant volume, by M. Ch. Antoine. For Regnault's curves of the form $x = A + Mt_s - Nt_s^2$, the author substitutes functions of the temperature t and of the tension p, such as $x = B + ct_s = \phi(p)$, deducing for aqueous vapour two determinations for specific heat under constant pressure and constant volume. Analogous formulas may be obtained for other vapours, such as ether, chloroform, acetone, benzene, chloride, and sulphide of carbon.—Papers were contributed by M. Léo Vignon on the action of water on stannic chloride; by M. G. Raulin, on the action of phosphates on the growth of cereals; by M. C. Timiriazeff, on the relation between the intensity of solar radiation and the decomposition of carbonic acid by plants; and by M. Armand Sabatier, on the zoological station at Cette.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Marine Aquaria: R. A. R. Bennett (Gill).—Narrative of an Explorer in Tropical South Africa; F. Galton (Ward, Lock).—The Mathematical Theory of Electricity and Magnetism; vol. ii. Magnetism and Electrodynamics: Watson and Burbury (Clarendon Press).—Bulletin of the U.S. National Museum; No. 34. The Batrachia of North America: E. D. Cope (Washington).—Bulletin of the U.S. National Museum; Contributions to the Natural History of the Cetaceans, a Review of the Family Delphinidæ: F. W. True (Washington).—Calcul des Probabilités: J. Bertrand (Paris, Gauthier-Villars).—Die Fossilen Pferde der Pampasformation: Dr. H. Burmeister (Buenos Aires).—Elementary Physiography, 2nd edition: G. Thom (Edinburgh, Thin).—The Eiffel Tower: G. Tissandier (Low).—Brain, July (Macmillan).—The Esclepiad, No. 23, vol. vi.: Dr. B. W. Richardson (Longmans).—Journal of the College of Science, Imperial University, Japan, vol. iii., Parts 1 and 2 (Tōkyō).

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THURSDAY, SEPTEMBER 12, 1889.

THE TECHNICAL INSTRUCTION ACT.

IN the Speech from the Throne at the close of the session, Her Majesty is made to express satisfaction, *inter alia*, with "the steps you have taken towards the establishment of technical education in England and Wales," and perhaps the words here placed in the Queen's mouth will do as well as any others to express the feeling with which the Government Bill was regarded by the friends of technical instruction all over the country, and by those who for years past have laboured in the cause. Steps have been taken "towards" the establishment of technical education in England and Wales, not very complete or large steps, but still steps which show that the Government, when time and opportunity arise, are prepared to go further, and which pledge the present Ministry, at any rate, to secondary technical instruction. That the new Act goes no further is not necessarily due to any lukewarmness on the part of the Vice-President of the Council or of his colleagues. The circumstances of the past few years were such that a very large amount of legislation had to be proposed, and if possible carried, during the session just ended; and any Government would naturally desire to avoid all contentious subjects except those which imperatively called for treatment. Unfortunately, nothing is easier than to revive in certain quarters in the House of Commons the heated educational controversies of twenty years ago; there are still some men whose blood is fired by these antique battle-cries, and who think it their duty to ride forth to a war in which there is nowadays no real enemy. We think that the friends of technical instruction have every reason to be grateful to a Government which, with many inducements to do nothing, have yet brought in and passed a Bill which, with Sir Henry Roscoe's amendments, was supported by all the members of the Royal Commission on Technical Instruction who had seats in the House of Commons. But, we hear it said, the Bill is a very poor and small measure, while the subject is one to be dealt with by a large, comprehensive, and elaborate enactment; the principle of the administration is all wrong, for it divides technical education from the ordinary education of the country,—it should be administered by the School Boards and by the School Boards only; it is mere paltry, tinkering legislation where it might be heroic, and so on. No doubt in the best of all possible worlds the matter would be different, but here below we have to take things as we find them; and amongst the things which we find, is a legislative machine which labours heavily and slowly, and which has to be manipulated with a hundred and one different considerations in view. The House of Commons is far, indeed, from being an ideally perfect assembly for dealing with technical education or any subject of the kind; but in this, as in most other matters in this country, where compromise governs in all things, from the position of the Queen on the throne downwards, the question is not what we ought to have, but what we can get. Things do not spring full-grown from the brain of the British Jove; we do not get complete, exhaustive, elaborate legislative enactments from the British Parliament; finality is never written on any of its proceedings; it never seeks theoretical perfection. First we get one small inadequate measure; by and by this is enlarged, amended, improved, supplemented, by a succession of Acts, spread, it may be, over years, and perplexing lawyers and administrators by their inconsistent and contradictory provisions; then last of all comes a reforming official who elaborates all these scattered Acts into one homogeneous statute, which he succeeds in getting through Parliament just as the whole becomes useless in consequence of some new policy or wave of public opinion; and then the process is all gone through again. As to the objection respecting the authority administering the Act, we must confess we cannot attach any weight to it, in comparison with the substantial concession to the demand for technical instruction which it makes. It seems to us that it can matter very little which particular one of our numerous local authorities is to be the medium for passing on to the public the benefits conferred by the Act. No doubt the work is more within the scope of the School Boards; but to refuse those benefits because, for reasons which are perfectly well understood by those who have followed the discussion, they come from County and Borough Councils and rural sanitary authorities, would be absurd pedantry—almost a crime. One member of the House of Commons was filled with dismay at the prospect of the rural and urban sanitary authorities raising technical institutes out of the public funds, although he quite approved of technical instruction. It does not appear that a technical institute will be any the worse because the money with which it is maintained will be raised by a number of men with one long name rather than a number with another long name: the public gets the institute all the same. Moreover, this point is rendered of little or no importance, even in itself, by the present position of local government in this country. It is now in a transition stage; most of the existing machinery which has not already been taken to pieces will certainly have to undergo that process in the course of the next few years, and we feel no assurance at all that School Boards themselves will not shortly disappear, to be replaced by Education Committees of County and Borough Councils, as existing sanitary authorities will be supplanted by Sanitary Committees and sub-committees. From this point of view, even if a great question of principle were otherwise involved, it would not matter much which set of authorities undertook the task, seeing that all are likely to be equally short-lived, and to be merged soon in the County or Borough Councils, as the case may be. What satisfies those true friends of our national progress who have made this subject their own in Parliament, and who are in specially favourable positions for judging what is attainable, will probably satisfy most other sensible advocates of technical instruction. In common phrase, the Act is "something to go on with"; it is even more, because it is a pledge that the Government will go further in due time. In an excellent and well-considered article on the subject, the *Times* (September 4) says it "remains for us to make the best use of the system about to be established, to take note of the dangers and drawbacks incidental to it, but not to forget the limitless possibilities for good which it offers," and further, "almost without a struggle is established the possibility of a complete national system of technical instruction." It is for this that we have reason to be thankful to the Government: it has placed the instrument in our hands, and it is for us now to use it efficiently.

CAMBRIDGE MATHEMATICS.

A History of the Study of Mathematics at Cambridge. By W. W. Rouse Ball. (Cambridge: University Press, 1889.)

AUGUSTUS DE MORGAN, writing more than fifty years ago, says that "the literary history of this country requires separate and minute accounts of the rise of science in Oxford, in Cambridge, and in the north of England, which should severally end (if it might be no later) with Wallis, Newton, and Thomas Simpson."[1] To what extent this long-felt want has been supplied by other publications, we cannot tell; but we know of none readily accessible to the student of mathematical history, and therefore hail with satisfaction the appearance of the small octavo volume which is the subject of our review.

What we should call the study of mathematics at Cambridge is of comparatively recent origin: for, although Seth Ward "brought mathematical learning into vogue in the University, . . . where he lectured his pupils in Master Oughtred's 'Clavis,'"[2] the first Mathematical Professor there was Isaac Barrow (Ward's junior by about twelve years), and the lectures of his illustrious successor were so ill attended that M. Bertrand says: "Il professa trente ans à Cambridge sans y former un disciple digne de lui; la salle du cours restait souvent déserte le jour de sa leçon, et Newton retournait alors tranquillement à ses travaux."[3] Oughtred, whose "Clavis Mathematica" was published in 1631, did not reside long at Cambridge: his secluded life is thus described by our author:—

"Although living in a country vicarage he kept up his interest in mathematics. Equally with Briggs he received one of the earliest copies of Napier's 'Canon' on logarithms, and was at once impressed with the great value of the discovery. Somewhat later in life he wrote two or three works. He always gave gratuitous instruction to any who came to him, provided they would learn to 'write a decent hand.' He complained bitterly of the penury of his wife, who always took away his candle after supper, 'whereby many a good motion was lost and many a problem unsolved'; and one of his pupils who secretly gave him a box of candles earned his warmest esteem. He is described as a little man, with black hair, black eyes, and a great deal of spirit. Like nearly all the mathematicians of the time, he was somewhat of an astrologer and alchemist. He died at his vicarage of Albury in Surrey on June 30, 1660."[4]

Mr. Ball leaves us in doubt as to the nature of the "two or three works" written "somewhat later in life" by Oughtred. Fortunately we are able to supply this omission from an old book[5] on our shelves, which says that

"Lord Napier, in 1614, publishing at Edinburgh his 'Mirifici logarithmorum canonis descriptio, ejusque usus in utraque trigonometria, &c.,' it presently fell into the hands of Mr. Briggs, then geometry-reader of Gresham College in London; and that gentleman, forming a design to perfect Lord Napier's plan, consulted Oughtred upon it; who probably wrote his 'Treatise of Trigonometry' about the same time, since it is evidently formed upon the plan of Lord Napier's 'Canon.' In prosecuting the same subject, he invented, not many years after, an instrument, called 'The Circles of Proportion.' . . . All such questions in arithmetic, geometry, astronomy, and navigation, as depended upon simple and compound proportion, might be wrought by it; and it was the first sliding rule that was projected for those uses, as well as that of gauging."

Authorities differ as to the day of Oughtred's death: thus the "Penny Cyclopædia" makes it happen on "Jan. 30th" (a misprint, probably, for the same day of June); in the article just quoted it is "about the beginning of May"; and in the historical introduction to Hammond's "Algebra"[6] we read that "he lived to the Age of Fourscore and Seven, and died then of Joy, on May 1, 1660, at hearing the House of Commons had voted the King's Return."

One circumstance compels us to reject this account: we cannot understand how Oughtred, living in the neighbourhood of Guildford, could know what took place in Parliament, on May 1, before the next day. But the mere fact of his death being currently attributed to such a cause illustrates so well the intense political excitement of the times in which he lived that it ought not to be passed over in silence. It is of more value than many boxes of candles.

From the time of Newton down to the beginning of the present century, mathematics (though diligently studied) made very little progress, either at Cambridge or in other parts of England. In Cambridge this was due to the excessive reverence paid to authority; at first by all, and afterwards by those "senior members of the senate, who regarded any attempt at innovation as a sin against the memory of Newton,"[7] and who were the worthy successors of the Cambridge dons described by Pope, in 1742, as

"A hundred head of Aristotle's friends."[8]

We may be mistaken, but we strongly suspect that one of them was William Farish (b. 1759, d. 1837), whose memory is embalmed in the following extract:—

"He is celebrated in the domestic history of the University for having reduced the practice of using Latin as the official language of the schools and the University to a complete farce. On one occasion, when the audience in the schools was unexpectedly increased by the presence of a dog, he stopped the discussion to give the peremptory order, *Verte canem ex.* At another time one of the candidates had forgotten to put on the bands which are

[1] "Notices of English Mathematical and Astronomical Writers between the Norman Conquest and the Year 1600." This important article appeared anonymously in the Companion to the Almanac for 1837, but was undoubtedly written by De Morgan, and in fact was claimed by him six years afterwards.

[2] Ball, p. 37. In referring to the work before us, both here and subsequently, for brevity we cite only the author's name and the number of the page.

[3] "Les Fondateurs de l'Astronomie Moderne" (8vo, Paris, n.d.) p. 303.

[4] Ball, p. 30.

[5] As no edition of this work is mentioned by De Morgan in his "References for the History of the Mathematical Sciences," we give its title in full, as follows: "A New and General Biographical Dictionary; containing an Historical and Critical Account of the Lives and Writings of the Most Eminent Persons in every Nation; particularly the British and Irish; from the Earliest Accounts of Time to the present Period. Wherein Their remarkable Actions and Sufferings, Their Virtues, Parts, and Learning, are Accurately Displayed. With a Catalogue of their Literary Productions. A New Edition, in Twelve Volumes, greatly enlarged and improved" (8vo, London, 1784).

[6] The third edition, 8vo. London, 1764.

[7] Ball, p. 117.

[8] "Dunciad," iv. 192. A note to this verse reads thus:—"The Philosophy of *Aristotle* had suffered a long disgrace in this learned University: being first expelled by the *Cartesian*, which, in its turn gave place to the *Newtonian*. But it had all this while some faithful followers in secret, who never bowed the knee to *Baal*, nor acknowledged any strange God in Philosophy."

still worn on certain ceremonial occasions. Farish, who was presiding, said, *Domine opponentium tertie, non habes quod debes. Ubi sunt tui. . . .* (with a long pause) *Anglice bands?* To whom with commendable promptness the undergraduate replied, *Dignissime domine moderator, sunt in meo* (*Anglice*) *pocket.* Another piece of scholastic Latin quoted by Wordsworth is, *Domine opponens non video vim tuum argumentum.*"[9]

In the last sentence "his scholastic Latin" would read better than "scholastic Latin": perhaps, however, this alteration could not be made without violating historic truth; in which case it might be difficult (but we hope not impossible) to substitute some other Latin sentence belonging undoubtedly to Farish, and anything like as good as his exquisite "*Verte canem ex.*" It is recorded, to the credit of Farish, that he resided and taught; a rare instance of virtue in a Professor of that period. Strange abuses were prevalent in his time; among them the practice of "huddling" the disputations in the schools may be mentioned.

"By the Elizabethan code every student before being admitted to a degree had to swear that he had performed all the statutable exercises. The additional number thus required to be performed were kept by what was called *huddling*. To do this a regent took the moderator's seat, one candidate then occupied the respondent's rostrum, and another the opponent's. *Recte statuit Newtonus*, said the respondent. *Recte non statuit Newtonus*, replied the opponent. This was a disputation, and it was repeated a sufficient number of times to count for as many disputations. The men then changed places, and the same process was repeated, each maintaining the contrary of his first assertion—an admirable practice, as De Morgan observed, for those who were going to enter political life. Jebb asserts that in his time (1772) a candidate in this way could, as a respondent, read two theses, propound six questions, and answer sixteen arguments against them, all in five minutes."

The above is extracted from the chapter devoted to the exercises in the schools. This and the one on the mathematical tripos (ix. and x.) are the two best chapters in the book, and contain a large mass of interesting matter; but since the substance of both is reprinted from the author's "Origin and History of the Mathematical Tripos" (Cambridge, 1880), with which many of our readers are doubtless acquainted, we refrain from making any further quotations from either. We need only say that together with chapter viii. (under the heading "The Organization and Subjects of Education") and chapter xi. ("Outlines of the History of the University") they constitute the second of the two well-defined portions into which the present work is divided, and give a clear though succinct account of the history of Cambridge and of the principal object of study there, from the earliest times to the date of the repeal of the Elizabethan statutes (1858), with which the history is made to terminate. The first seven chapters, which (see the preface) "are devoted to an enumeration of the more eminent Cambridge mathematicians, arranged chronologically," embrace the same period of time. Their style is somewhat similar to that of the author's "History of Mathematics" published last year, but is still more concise. In them, with the assistance afforded by the introductory paragraphs prefixed to each, we are enabled to trace the rise of mathematical science from the earliest times to the death of Newton (i. to iv.), and its subsequent decadence in Cambridge (v. and vi.), until we come to chapter vii., which is mainly occupied with those mathematical reforms (initiated by Robert Woodhouse, and carried out by Peacock, Herschel, Babbage, and others) which inaugurated the great modern revival of learning in England, spoken of by Mr. Ball in his concluding paragraph as the "new renaissance." The first portion of the work terminates with this chapter, which also contains notices of some of the more prominent mathematicians who graduated at Cambridge since the time of the above-mentioned reformers, but not later than the Tripos of 1859. Except in the ninth and tenth chapters, the style is too condensed, and conciseness is sometimes attained by the suppression of interesting facts; but this is not an unmixed evil, since the cost of publication is thereby kept down, and we have every reason to believe that those who are content to pay a moderate price for a general view of the subject will find in this little volume a very useful compendium of Cambridge mathematical history.

We ought to add that, in its externals, the book is all that most attracts the fastidious purchaser. It is neatly bound, in general correctly printed, in clear type, and on good paper. The table of contents and index are also good.[10]

[9] Ball, p. 106.

[10] In this note we append a few disjointed remarks for the sake of pointing out certain trivial *errata*, and small emendations, or what we believe to be such:—

P. 17, "belated traveller." A man who had travelled no farther than from St. James's Park to Whitefriars (see "The Fortunes of Nigel," ch. xvi. and xvii.) and who had remained in sanctuary there for some days, can hardly be called a belated traveller because he asks for "a book—any sort of book—to pass away the night withal," and we can discover no other reason. The passage we allude to occurs in ch. xxiv. of Scott's novel, and in the version from which we quote runs thus:—"*She heard with interest Lord Glenvarloch's request to have a book—any sort of book—to pass away the night withal, and* returned for answer, that she knew of no other books in the house than her young mistress's (*as she always denominated Mistress Martha Trapbois*) Bible, which the owner would not lend; and her Master's Whetstone of Witte, *being the second part of Arithmetic*, by Robert Record, *with the Cossike Practice and Rule of Equation; which promising volume Nigel declined to borrow.*" This is quoted both by De Morgan and Mr. Ball, of whom the latter omits the italicized words, and the former those only that are also underlined. Both of them omit the comma between "answer" and "that"; and both spell "Bible" with a small "b," "Master's" with a small "m," and "Record" with a final "e." From this we infer that both of them quoted from a version of Scott differing from the one on our shelves in the above particulars, unless Mr. Ball copied his quotation from De Morgan's. The fact that De Morgan makes no allusion to a "belated traveller" seems to favour the former theory. Our author deals with Recorde just as he has done with Scott: he takes a passage from him, gives certain portions of it, and modernizes the spelling (see the quotations from Recorde on pp. 16–18, and compare them with those given in the article by De Morgan, referred to in note [1], which contains all of them and is easily procurable). The ghost of an old author has a right to complain of the alteration of a single letter in his work, and to say "Interpretation will misquote our *b*ooks" (Hen. IV., Part I., act v., sc. 2). There! we have committed the very offence we felt called upon to condemn, and have changed Shakespeare's "l" into a "b."

P. 31. For "*circle of proportion*" read "*circles of proportion.*"

P. 41. The first volume of Marie's "Histoire des Sciences mathématiques" was published in 1883: this date is changed into 1833 by an obvious misprint.

P. 72. The correct title of Dr. Sloman's work (which lies open before us as we write) is, "The claim" (not claims) "of Leibnitz to the invention of the differential calculus."

P. 91. Smith's "Compleat System of Opticks" was published in 1738 (not 1728). An advertisement dated "*London*, Apr. 25, 1738," speaks of it as "Printing at *Cambridge* in Quarto, and will be published by the latter end of *May* or the beginning of *June*" (we quote *literally*).

P. 93. It is not easy to identify books whose titles are not given, but we know of no text-book by Humphry Ditton "on the infinitesimal calculus" of an earlier date than 1706, when his "Institution of Fluxions" was published. We therefore conclude that the date 1704 must be a misprint for 1706, and shall continue to think so until we actually see an edition dated 1704.

On this page also, for "Robert Smith (1728)" read "Robert Smith (1738)."

P. 257. In the index, insert the reference "Commercium Epistolicum, 72"; for "Creswell" read "Cresswell;" and in the third line of the references to De Morgan, *dele* 180.

We have given the above list in compliance with the words, "I shall thankfully accept notices of additions or corrections which may occur to any of my readers," with which Mr. Ball's preface terminates.

DE LAPPARENT'S "MINERALOGY."

Cours de Minéralogie. Par A. de Lapparent. 2me édition. (Paris: F. Savy, 1890.)

SIX years have elapsed since our announcement in NATURE of the appearance of this book, and now the call for a second edition indicates the continually increasing popularity of the work, not only in France, but especially abroad, where more than half of the first edition has been sold. This popularity must be ascribed mainly to the fact that M. de Lapparent's "Cours de Minéralogie" was the first educational work in which the crystallographic theories of Bravais and Mallard were expounded as a system, and constituted, one may say, the basis of his lectures.

Now that these theories are continually obtaining a more favourable reception, it must be recognized that their diffusion has been largely effected by the present "Cours de Minéralogie," owing mainly to the remarkable power of exposition possessed by M. de Lapparent, of which he gave us a new proof when he published his lectures on mineralogy in 1884. The same quality is eminently conspicuous in this edition; but let us hasten to remark that the present is in reality a new work, which contains nearly 100 pages more than the first edition and a large number of new figures. A glance is sufficient to show that the author has not been content with revision, but has entirely reconstructed the book. He has so developed the optical portion that the volume becomes a sufficient introduction to the study of petrography, this chapter now containing a description of the refractometer, the quarter-wave-length mica, and Bertrand's plate; attention may also be directed to the paragraph on complex molecules (p. 22), and to the demonstration of the terquaternary system (p. 55); he has, moreover, grouped in a series of chapters, which constitute a homogeneous and strikingly uniform treatise on the subject, the elegant theories of Mallard upon twinning, isomorphism, and polymorphism. The description of species has been considerably increased, especially by the extended account of the rock-forming minerals; and the characters in microscopic sections of the minerals which are most important in lithology are illustrated by figures selected from the best authorities. In his own words, the author, taught by experience and knowing how necessary it is that numbers should be verified, has revised all the crystallographic data; he has given for each species the corresponding axial ratios after imposing upon himself the task of verifying by trigonometrical calculation the agreement of these ratios with the fundamental angles; and he has selected from the latest and best publications the optical data, such as double refraction, dispersion, principal indices of refraction, and the numbers which indicate the positions of the optic axes and bisectrices.

Finally the index has been subjected to careful revision, and has been augmented by 200 names which represent the progress of descriptive mineralogy during the last six years. Since, moreover, the chapter on calculation has been developed and contains all the formulæ in common use, the practical value of the book has been largely increased, and it should satisfy every requirement of the University student; it will prove of special service to geologists occupied with the study of rocks, the class of readers whom the author appears to have continually had in his mind in the composition of a treatise in which the geological bias is discernible both in the classification adopted, and in the manner in which the description of the rock-forming minerals has been developed.

In a word, this work not only affords a good general idea of all that constitutes modern mineralogy, but is also a useful introduction to the study of lithology.

We are convinced that the book, written with the remarkable lucidity and elegance which characterize the works of M. de Lapparent, is destined to occupy the same position in the study of mineralogy which in geology has been held by the same author's "Traité de Géologie."

A. F. RENARD.

OUR BOOK SHELF.

Key to Higher Algebra. By H. S. Hall, M.A., and S. R. Knight, B.A. (London: Macmillan and Co., 1889.)

THIS work forms a key to the higher algebra, and contains solutions fully worked out of nearly all the examples. More than one solution of a problem is given in some cases, and throughout the book repeated references are made to the text and illustrative examples of the algebra. The volume will prove most useful to teachers, and we strongly recommend it to students who are beginning the study of algebra without the aid of a teacher, for, by first of all trying to work out the examples without the key, they may learn much by a careful and judicious use of the solutions afterwards.

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.*]

On the Use of the Word Antiparallel.

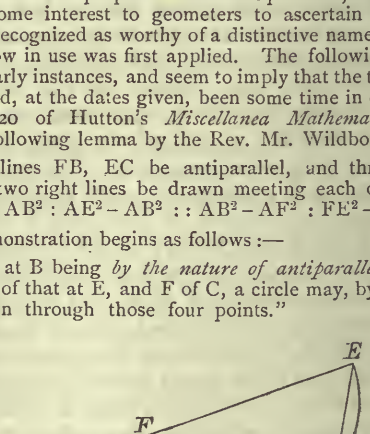
So much of the "recent geometry of the triangle" is connected with the properties of "antiparallels," that it is a matter of some interest to geometers to ascertain when they came to be recognized as worthy of a distinctive name, and when the name now in use was first applied. The following extracts afford two early instances, and seem to imply that the term "antiparallel" had, at the dates given, been some time in existence.

On p. 220 of Hutton's *Miscellanea Mathematica* (1775) occurs the following lemma by the Rev. Mr. Wildbore:—

"If two lines FB, EC be antiparallel, and through their extremities two right lines be drawn meeting each other in A, it will be as $AB^2 : AE^2 - AB^2 :: AB^2 - AF^2 : FE^2 - BC^2$";

and the demonstration begins as follows:—

"The $<$ at B being *by the nature of antiparallel lines* the supplement of that at E, and F of C, a circle may, by Eucl. III. 22, be drawn through those four points."

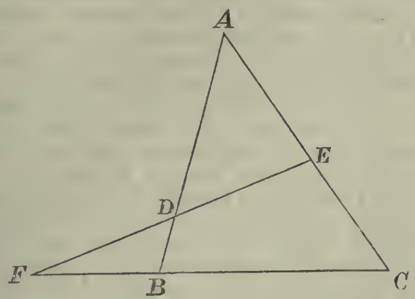


After the lemma occurs this "Scholium":—

"The reader may from hence correct an error in 'Clark's Dictionary' under the word *antiparallels*, where it is said that the sides AE, AC are cut reciprocally proportional by the line FB; that is, AF : FE :: BC : AB, which is evidently wrong."

In Hutton's "Mathematical and Philosophical Dictionary" (1796) we find:—

"ANTIPARALLELS, in geometry, are those lines which make equal angles with two other lines but contrary ways; that is, calling the former pair the 1st and 2nd lines, and the latter pair the 3rd and 4th lines, if the angle made by the 1st and 3rd lines be equal to the angle made by the 2nd and 4th, and, contrariwise, the angle made by the 1st and 4th equal to the angle made by the 2nd and 3rd; then each pair of lines are antiparallels with respect to each other, viz. the 1st and 2nd, and the 3rd and 4th.



"So if AB and AC be any two lines, and FC, FE two others cutting them so that the angle B is equal to the angle E and the angle C is equal to the angle D; then BC and DE are antiparallels with respect to AB, AC; also these latter are antiparallels with respect to the two former."

It is curious also to note an error as regards the ratios of the segments of the sides, similar to but not identical with the one pointed out by the contributor to the *Miscellanea Mathematica* as occurring in "Clark's Dictionary"; for the next paragraph states:—

"It is a property of these lines that each pair cuts the other into proportionate segments, taking them alternately;

viz. AB : AC :: AE : AD :: DB : EC
and FE : FC :: FB : FD :: DE : BC."

Here the third ratio in each line is wrongly stated to be equal to the two which precede it; for keeping the triangle ABC and therefore also the direction of FE fixed, it is clear that the ratios AB : AC, AE : AD remain fixed, while DB : EC may range from zero to infinity.

E. M. LANGLEY.

The Force of "Example" in Animals.

SOME years ago we had two cats—a tabby, and a powerful tom perfectly white all over. One day I happened to be in the attic, and noticed them go out on the slates, when Tom jumped across the yard to the next roof. It appeared to me a splendid leap, considering the width of the yard and the height of the roof. When Tabby came to the edge of the slates her courage failed, and she uttered a cry of distress, whereupon Tom turned round and leaped back, and giving a cheerful mew as much as to say, "Look how easily it can be done," jumped across again, this time followed by Tabby, to my great delight.

φ.

"Astrarchia stephaniæ."

IN the interesting "Geographical Notes" from New Guinea, published in NATURE of September 5 (p. 449), it is stated that Sir William MacGregor procured, among others, "a female *Astrachia stephania*, the only male bird of that species being in the Museum, Berlin." Will you permit me to rectify this in communicating to you that the only male *Astrarchia stephaniæ* is in the Zoological Museum of Dresden. The bird was described and figured by Dr. Finsch and myself in the year 1885, and the name is correctly written as I have just given it.

Dresden, September 8.

A. B. MEYER.

THE RECENT GREAT EARTHQUAKES IN JAPAN.

FULL details have now been received of the recent earthquakes in Japan. According to the report of the Governor of the Kumamoto district, in the Island of Kiushiu, the centre of the earthquake was a mountain situated to the west of Kumamoto, the chief town in the province of Higo. Knipo is one of a chain of volcanoes connected with Mount Aso, one of the most noted volcanoes in the country, which was visited and described a few years ago by Prof. Milne, who regards it as one of the two or three largest volcanoes in the world. No eruption, however, has ever as yet taken place there, but fears are now entertained of a terrible eruption; rumblings have been heard, and the mountain has discharged lava in several places. Aso Yama, or Mount Aso, has for many years been known as the only active volcano on the Island of Kiushiu. This mountain rises to a height of nearly 5000 feet. Its last eruption was in 1874, when a large quantity of grayish-white pumice ashes was discharged. It would seem, however, that more or less constant discharges have taken place at intervals ever since the premonitory signs. On the morning of July 28, the day of the destructive shock, the weather was agreeably cool, but at twilight the sky was clothed with a dark cloud tinged with a pale reddish colour, and the atmosphere became quite close. About ten minutes past eleven p.m. a noise as of thunder was heard. Simultaneously a strong earthquake movement commenced. As the nature of the shock was unusual, some of the inhabitants dressed, whilst others with scarcely any clothing, rushed from their houses, a number of them only to be crushed to death by falling walls and trees. The Castle of Kumamoto, which was the scene of the memorable siege by General Saigo at the time of the Kagoshima rebellion, and is noted for the solidity of its structure, was damaged in several parts. In the streets fissures appeared in several places, some of the cracks measuring six feet in width. In other parts of the town subsidences occurred; in some instances water was seen spouting from the fissures created by the seismological disturbance. There were several incipient fires caused by the overturning of lamps, but they were speedily extinguished, and much additional loss of property was thus avoided. Houses were overturned and the occupants killed. The first shock was soon followed by several smaller and two severe ones. With the break of day the dull cloud moved off, to leave the sky covered with yellowish little patches. The most severe shock was the first one, when even unusually strong houses were almost displaced from their foundations. Old houses and those not very strongly built were brought to the ground with sufficient force to kill, and in other cases injure numbers of persons. The losses sustained by chemists and china-ware merchants were large, owing to the breakage among their brittle stock. All wells in Kumamoto have either been rendered so foul with mud as to make them useless, or are dry by reason of the escape of water. The city is being temporarily forsaken by those who can afford to remove their families. In the town of Kumamoto the list of casualties is three persons crushed to death and six wounded. Twenty-two houses were thrown down and sixteen partially wrecked. In the neighbouring district of Akita, however, the force of the shock seems to have been felt more severely. Fifteen lives were lost, thirteen persons were injured, and thirty-two dwellings were overthrown, while many farmhouses were more or less damaged. In Sage, also a district of Kiushiu, there were underground sounds as of many cannons; then ensued prolonged vibrations from south to north-west, dwellings leaning over at inclinations varying from 70° to 80°, accompanied by loud crackling of posts and walls. The ground quivered so that pedestrians stumbled and fell. This shock continued for about four minutes. During the night there were two other disturbances, the last being the most severe. The greatest disorder and fright prevailed, and a night of terror was passed in the open air by the unclad population. In the districts of Sakanami and Kami-Tunaki the ground for a space of 9 acres began to crack on July 28, and the phenomenon continued until the whole surface was covered with a network of fissures. According to the latest accounts, fifty-three distinct shocks had been felt, only two or three of them being severe. Within twelve hours on August 3, thirty-five earthquakes were experienced at Kumamoto, one of which caused the ground to open in no fewer than twelve places.

THE UNITED STATES ECLIPSE EXPEDITION.

THE Navy Department in Washington is now fitting out an Expedition to Angola, on the west coast of Africa, to observe the total eclipse of the sun which will be visible there on the afternoon of December 22 next. Prof. Todd, of Amherst College, has been appointed chief of the party, a position similar to that which he held two years ago in conducting the Eclipse Expedition to Japan.

The party, which will be a large one, will leave New York about October 1, in a Government cruiser. The natural history department of the Expedition will be under the charge of Dr. Wm. J. Holland, of Pittsburg, who will make large collections and extensive investigations, especially in entomology, which is his special department. He filled a similar position in the Expedition to Japan in 1887. Work will be done in many directions, and even if the weather or any accident should render a successful observation of the eclipse impossible, the Expedition will have a great amount of valuable information and collections when it returns.

After landing at St. Paul de Loanda, 250 miles south of the mouth of the Congo, the Expedition will go about one hundred miles into the interior, in order to be on higher land, and out of the fever belt on the coast. The eclipse, which will occur on December 22, 1889, at about 3 p.m., will be total for a little over three minutes at the station south-east of Loanda. The whole length of the eclipse will be between two and three hours. In photographing its different phases, if the sky is clear, it is hoped that about 150 photographs will be taken, with the largest telescope ever used for photographing an eclipse. This will give an image of the sun about 4½ inches in diameter. Owing to the number of fine instruments which have to be carefully transported and adjusted, about two months will be spent at the observation station, and the party will be absent about five or six months altogether. The particular point where it is hoped a settlement may be made is Muxima on the Quanza River. In reply to a question as to the instruments he would take with him, Prof. Todd is reported to have said:—

"Some of them will be the same as I had in Japan, especially the great telescope, forty feet long, to get pictures of the different stages of the eclipse with. It is the same sort of a telescope that I used in photographing the transit of Venus in 1882 at the Lick Observatory. But photographing the corona is not the main thing nowadays in eclipses. All that has gone by. There are other questions of much more importance than merely to find out how the corona looks. It is a very complex phenomenon. The sources of its light are not known, and the streamers of light are in parts superposed or overlapping. The most important thing to do is to take photographs in such a way that the intensity of the light in every part can be accurately measured, and to photograph the spectrum of as many separate portions of the coronal light as possible. We are making much progress in this direction, but the old methods of eclipse photography in use ten or fifteen years ago yielded very insufficient results, and there is relatively little use in following them up if the more advanced and specialized work is not undertaken. Of course they are good as far as they go. Then I shall have several new devices, which my previous experience, particularly in Japan, has led to the invention of. Among other things I have devised a revolving plate holder, which will enable us to get the largest possible number of pictures at the critical moments."

URANIUM.

EXACTLY a century ago—namely, in 1789—Klaproth succeeded (says the *Times*) in isolating from a dark-coloured mineral known as pitchblende a yellow oxide, which, after carefully testing, he pronounced to be the oxide of a new metal. To this metallic substance he gave the name of uranium, so calling it after the planet Uranus, then recently discovered by Herschel, and it was at once classed among the rare metals, and still remains so. Its rarity is indicated by its market price, which is about £2400 per ton. There are several oxides of this metal; but the best known and most important is the sesquioxide, which forms a number of beautiful yellow salts. This oxide is largely employed for imparting delicate golden and greenish yellow tints to glass, while the protoxide is much used in producing the costly black porcelain. Uranium is also found to be useful in certain photographic processes as a substitute for the chloride of gold; but its rarity and consequent high price have hitherto caused its application to be very limited, although there are uses other than those already named to which it could be put if it were less scarce and less costly. It is found in Cornwall, Saxony, and Bohemia; but up to the present time it has only been met with in isolated pockets and patches. The centenary of its discovery by Klaproth has, however, been marked by the finding of a continuous lode at the Union Mine, Grampound Road, Cornwall, which is believed to be the only known lode in the world. This discovery is regarded as unique in the history of the metal, for the lode is what is known as a true fissure vein, and the ore is found to contain an average of 12 per cent. of the pure metal, the assays going up as high as 30 per cent. in some parts of the lode. Several tons of the ore have already been raised and sold, fetching high prices. The lode traverses the mine from north to south, and the uranium occurs in it chiefly as a sesquioxide. It is anticipated that the present discovery will enable two important applications of the metal to be followed up. The first is as a substitute for gold in electroplated ware, inasmuch as with platinum and copper it forms two beautiful alloys, each having the appearance of gold, and the former also resisting the action of acids. The second application is in connection with electric installations, where its usefulness consists in its high electrical resistance. The mineral deposits generally at the Union Mine are of an exceptional character, comprising, in addition to uranium, magnetic iron, silver lead, tin, copper, ochre, and umber.

THE BRITISH ASSOCIATION.

NEWCASTLE, *Tuesday Night.*

IT is impossible at this stage to say what will be the character of the third Newcastle meeting, so far as numbers are concerned. In one quarter I am informed it is not expected that the attendance will be above the average, while another authority, who ought to know, assures me the numbers will be greater than was the case even at the Manchester meeting. For it should be remembered that, until that meeting, Newcastle topped the record so far as numbers go. To judge from the aspect of the Reception Room, not many people have yet arrived, though doubtless they will come in by later trains, and tomorrow morning. So far as I have been able to learn, very few foreign men of science of distinction are expected. Universal regret is expressed that the serious illness of Dr. Burdon Sanderson will prevent his taking his place as President of Section D; his address, which promises to be one of much interest, will be read by one of the Vice-Presidents. The proceedings in this Section, it is expected, will be somewhat lively; more than one paper will be read on certain aspects of Darwinism, and, as vigorous controversialists of different schools will be present, some strong speaking may be looked for.

So far as the efforts of the Local Committee go, the meeting ought to be a success. It is evident that everything has been done, so far as the accommodation of Newcastle permits, for the convenience and comfort of the visitors. The Durham College of Medicine makes very excellent Reception and Reading Rooms. Smoking Rooms, Luncheon Rooms, and other conveniences that conduce to the comfort of visitors, have been provided and well equipped. The St. George's Drill Hall is large enough for the opening address and the lectures, but the quality of its acoustic properties is feared. One of the great social events of the meeting will be the banquet given by Lord Armstrong, on Thursday night, to 200 guests; while the favourite excursion is that to Durham on Saturday, when the Warden and Professors of the University will entertain 200 at lunch. Regret is expressed that the excursion to the Roman Wall has not been fixed for the Saturday instead of the Thursday. Indeed, the Thursday excursions—to Berwick, Bamburgh, Holy Island, Barnard Castle, and other places—are likely to induce many visitors to stay over that day.

Geologists are looking forward with much interest to Dr. A. Geikie's paper on his recent visit to Norway, as well as to Prof. James Geikie's address as President of the Section. Prof. Flower's address will be devoted mainly to the arrangement of Museums.

It may be worthy of note that the Economical Section will be conducted on much more scientific lines than has been hitherto the case.

Inaugural Address by Prof. W. H. Flower, C.B., LL.D., F.R.S., F.R.C.S., Pres.Z.S., F.L.S., F.G.S., President.

It is twenty-six years since this Association met in Newcastle-upon-Tyne. It had then the advantage of being presided over by one of the most distinguished and popular of your fellow-townsmen.

Considering the age usually attained by those upon whom the honour of the presidency falls, and the length of time which elapses before the Association repeats its visit, it must have rarely happened that anyone who has held the office is spared, not only to be present at another meeting in the town in which he has presided, but also to take such an active part in securing its success, and to extend such a hospitable welcome to his successor, as Lord Armstrong has done upon the present occasion.

The address which was delivered at that meeting must have been full of interest to the great majority of those present. It treated of many subjects more or less familiar and important to the dwellers in this part of the world, and it treated them with the hand of a master, a combination which always secures the attention of an audience.

When it came to my knowledge that in the selection of the President for this meeting the choice had fallen upon me, I was filled with apprehension. There was nothing in my previous occupations or studies from which I felt that I could evolve anything in special sympathy with what is universally recognized as the prevailing genius of the district. I was, however, somewhat reassured when reminded that in the regular rotation by which the equal representation in the presidential office of the different branches of science included in the Association is secured, the turn had come round for some one connected with biological subjects to occupy the chair, which during the past seven years has been filled with such distinction by engineers, chemists, physicists, mathematicians, and geologists. I was also reminded that the Association, though of necessity holding its meeting in some definite locality, was by no means local in its character, but that its sphere was co-extensive, not with the United Kingdom only, but with the whole of the British Dominions, and that our proceedings are followed with interest wherever our language is understood—I may say, throughout the civilized world. Furthermore, although its great manufacturing industries, the eminence of its citizens for their skill and intelligence in the practical application of mechanical sciences, and the interesting and important geological features of its vicinity, have conferred such fame on Newcastle as almost to have overshadowed its other claims to distinction in connection with science, this neighbourhood is also associated with Bewick, with Johnson, with Alder, Embleton, Hutton, Atthey, Norman, the two Hancocks, the two Bradys, and other names honoured in the annals of biology; it has long maintained a school of medicine of great repute; and there has lately been established here a natural history museum, which in some of its features is a model for institutions of the kind, and which, I trust, will be a means of encouraging in this town some of the objects the Association was designed to promote.

There can be no doubt that among the various methods by which the aims of the British Association (as expressed in its full title, *the advancement of science*) may be brought about, the collection and preservation of objects available for examination, study, and reference—in fact, the formation of what are now called "museums"—is one of very great practical importance; so much so, indeed, that it seems to me one to the consideration of which it is desirable to devote some time upon such an occasion as this. It is a subject still little understood, though, fortunately, beginning to attract attention. It has already been brought before the notice of the Association, both in Presidential and Sectional addresses. A committee of our members is at the present time engaged in collecting evidence upon it, and has issued some valuable reports. During the present year an association of curators and others interested in museums has been founded for the purpose of interchange of ideas upon the organization and management of these institutions. It is a subject, moreover, if I may be allowed to mention a personal reason for bringing it forward this evening, which has more than any other occupied my time and my attention almost from the earliest period of my recollection, and I think you will agree with the opinion of one of my distinguished predecessors in this chair, "that the holder of this office will generally do better by giving utterance to what has already become part of his own thought than by gathering matter outside of its habitual range for the special occasion. For," continued Mr. Spottiswoode, "the interest (if any) of an address consists not so much in the multitude of things therein brought forward as in the individuality of the mode in which they are treated."

The first recorded institution which bore the name of museum, or temple or haunt of the Muses, was that founded by Ptolemy Soter at Alexandria about 300 B.C.; but this was not a museum in our sense of the word, but rather, in accordance with its etymology, a place appropriated to the cultivation of learning, or which was frequented by a society or academy of learned men devoting themselves to philosophical studies and the improvement of knowledge.

Although certain great monarchs, as Solomon of Jerusalem and Augustus of Rome, displayed their taste and their magnificence by assembling together in their palaces curious objects brought from distant parts of the world—although it is said that the liberality of Philip and Alexander supplied Aristotle with abundant materials for his researches—of the existence of any permanent or public collections of natural objects among the ancients there is no record. Perhaps the nearest approach to such collections may be found in the preservation of remarkable specimens, sometimes associated with superstitious veneration, sometimes with strange legendary stories, in the buildings devoted to religious worship. The skins of the gorillas brought by the navigator Hanno from the West Coast of Africa, and hung up in the temple at Carthage, afford a well-known instance.

With the revival of learning in the Middle Ages, the collecting instinct, inborn in so many persons of various nations and periods of history, but so long in complete abeyance, sprang into existence with considerable vigour, and a museum, now meaning a collection of miscellaneous objects, antiquities as well as natural curiosities, often associated with a gallery of sculpture and painting, became a fashionable appendage to the establishment of many wealthy persons of superior culture.

All the earliest collections, comparable to what we call museums, were formed by and maintained at the expense of private individuals: sometimes physicians, whose studies naturally led them to a taste for biological science; often great merchant princes, whose trading connections afforded opportunities for bringing together things that were considered curious from foreign lands; or ruling monarchs in their private capacity. It every case they were maintained mainly for the gratification of the possessor or his personal friends, and rarely, if ever, associated with any systematic teaching or public benefit.

One of the earliest known printed catalogues of such a museum is that of Samuel Quickelberg, a physician of Amsterdam, published in 1565 in Munich. In the same year Conrad Gesner published a catalogue of the collection of Johann Kentmann, a physician of Torgau in Saxony, consisting of about 1600 objects, chiefly minerals, shells, and marine animals. Very soon afterwards we find the Emperor Rudolph II. of Germany busily accumulating treasures which constituted the foundations of the present magnificent museums by which the Austrian capital is distinguished.

In England the earliest important collectors of miscellaneous objects were the two John Tradescants, father and son, the latter of whom published, in 1656, a little work called "Musæum Tradescantianum; or, a Collection of Rarities preserved at South Lambeth neer London." The wonderful variety and incongruous juxtaposition of the objects contained in this collection make the catalogue very amusing reading. Under the first division, devoted to "Some Kindes of Birds, their Egges, Beaks, Feathers, Clawes and Spurres," we find "Divers sorts of Egges from Turkie, one given for a Dragon's Egge"; "Easter Egges of the Patriarch of Jerusalem"; "Two Feathers of the Phœnix Tayle"; "The Claw of the bird Rock, who, as Authors report, is able to trusse an Elephant." Among "whole birds" is the famous "Dodar from the Island Mauritius; it is not able to flie, being so big." This is the identical specimen, the head and foot of which have passed through the Ashmolean into the University Museum of Oxford; but we know not what has become of the claw of the Rock, the Phœnix tayle, and the Dragon's egg. Time does not allow me to mention the wonderful things which occur under the head of "Garments, Vestures, Habits, and Ornaments," or the "Mechanick, Artificial Workes in Carvings, Turnings, Sowings, and Paintings," from Edward the Confessor's knit gloves, and the famous "Pohatan, King of Virginia's habit, all embroidered with shells or Roanoke," also still at Oxford, and lately figured and described by Mr. E. B. Tylor, to the "Cherry-stone, upon one side S. George and the Dragon, perfectly cut, and on the other side 88 Emperours' faces," or the other "cherry-stone, holding ten dozen of tortoisshell combs made by Edward Gibbons." But before leaving these private collections I cannot forbear mentioning, as an example of the great aid they often were in advancing science, the indebtedness of Linnæus in his early studies to the valuable zoological museums, which it was one of the ruling passions of several Kings and Queens of Sweden to bring together.

Upon the association of individuals together into societies to promote the advancement of knowledge, these bodies in their corporate capacity frequently made the formation of a museum part of their function. The earliest instance of this in our country was the museum of the Royal Society in Crane Court, of which an illustrated catalogue was published by Dr. Grew in 1681.

The idea that the maintenance of a museum was a portion of the public duty of the State or of any municipal institution had, however, nowhere entered into the mind of man at the beginning of the last century. Even the great teaching bodies, the Universities, were slow in acquiring collections; but it must be recollected that the subjects considered most essential to the education they then professed to give were not those which needed illustration from the objects which can be brought together in a museum. The Italian Universities, where anatomy was taught as a science earlier and more thoroughly than anywhere else in Europe, soon found the desirability of keeping collections of preserved specimens, and the art of preparing them attained a high degree of excellence at Padua and Bologna two centuries ago. But these were generally the private property of the professors, as were nearly all the collections used to illustrate the teaching of anatomy and pathology in our country within the memory of many now living.

Notwithstanding the multiplication of public museums during the present century, and the greater resources and advantages which many of these possess, which private collectors cannot command, the spirit of accumulation in individuals has happily not passed away, although generally directed into rather different channels than formerly. The general museums or miscellaneous collections of old are now left to Governments and institutions which afford greater guarantee of their permanence and public utility, while admirable service is done to science by those private persons with leisure and means who, devoting themselves to some special subject, amass the materials by which its study can be pursued in detail either by themselves or by those they know to be qualified to do so; which collections, if they fulfil their most appropriate destiny, ultimately become incorporated, by gift or purchase, in one or other of the public museums, and then serve as permanent factors in the education of the nation, or rather of the world.

It would be passing beyond the limits of time allotted to this address, indeed going beyond the scope of this Association, if I were to speak of many of the subjects which have pre-eminently exercised the faculties of the collector and formed the materials of which museums are constructed. The various methods by which the mind of man has been able to reproduce the forms of natural objects or to give expression to the images created by his own fancy, from the rudest scratchings of a savage on a bone, or the simplest arrangement of lines employed in ornamenting the roughest piece of pottery, up to the most lovely combinations of form and colour hitherto attained in sculpture or in painting, or in works in metal or in clay, depend altogether on museums for their preservation, for our knowledge of their condition and history in the past, and for the lessons which they can convey for the future.

Apart from the delight which the contemplation of the noblest expressions of art must produce in all cultivated minds, apart also from the curiosity and interest that must be excited by all the less successfully executed attempts to produce similar results, as materials for constructing the true history of the life of man, at different stages of civilization, in different circumstances of living, and in divers regions of the earth, such collections are absolutely invaluable.

But I must pass them by in order to dwell a little more in detail upon those which specially concern the advancement of the subjects which come under the notice of this Association—museums devoted to the so-called "natural history" sciences, although much which will be said of them will doubtless be more or less applicable to museums in general.

The terms "*natural history*" and "*naturalist*" have become deeply rooted in our language, but without any very definite conception of their meaning or the scope of their application. Originally applied to the study of all the phenomena of the universe which are independent of the agency of man, natural history has gradually narrowed down in most people's minds, in consequence of the invention of convenient and generally understood and accepted terms for some of its various subdivisions, as astronomy, chemistry, geology, &c., into that portion of the subject which treats of the history of creatures endowed with life, for which, until lately, no special name had been invented. Even from this limitation botany was gradually disassociating itself in many quarters, and a "naturalist" and a "zoologist" have nearly become, however irrationally, synonymous terms. The happy introduction and general acceptance of the word "biology," notwithstanding the objections raised to its etymological signification, has reunited the study of organisms distinguished by the possession of the living principle, and practically eliminated the now vague and indefinite term "natural history" from scientific terminology. As, however, it is certain to maintain its hold in popular language, I would venture to suggest the desirability of restoring it to its original and really definite signification, contrasting it with the history of man and of his works, and of the changes which have been wrought in the universe by his intervention.

It was in this sense that, when the rapid growth of the miscellaneous collections in the British Museum at Bloomsbury (the expansion of Sir Hans Sloane's accumulation in the old Manor House at Chelsea) was thought to render a division necessary, the line of severance was effected at the junction of what was natural and what was artificial; the former including the products of what are commonly called "natural" forces, unaffected by man's handiwork, or the impress of his mind. The departments which took cognizance of these were termed the "Natural History Departments," and the new building to which they were removed the "Natural History Museum."

It may be worth while to spend a few moments upon the consideration of the value of this division, as it is one which concerns the arrangement and administration of the majority of museums.

Though there is very much to be said for it, the objection has been raised that it cuts man himself in two. The illustrations of man's bodily structure are undoubtedly subjects for the zoologist. The subtile gradations of form, proportion, and colour which distinguish the different races of men, can only be appreciated by one with the education of an anatomist, and whose eye has been trained to estimate the value of such characters in discriminating the variations of animal forms. The subjects for comparison required for this branch of research must therefore be looked for in the zoological collections.

But the comparatively new science of "anthropology" embraces not only man's physical structure: it includes his mental development, his manners, customs, traditions, and languages. The illustrations of his works of art, domestic utensils, and weapons of war are essential parts of its study. In fact it is impossible to say where it ends. It includes all that man is or ever has been, all that he has ever done. No definite line can be drawn between the rudest flint weapon and the most exquisitely finished instrument of destruction which has ever been turned out from the manufactory at Elswick, between the rough representation of a mammoth, carved by one of its contemporary men on a portion of its own tusk, and the most admirable production of a Landseer. An anthropological collection, to be logical, must include all that is in not only the old British Museum but the South Kensington Museum and the National Gallery. The notion of an anthropology which considers savages and prehistoric people as apart from the rest of mankind may, in the limitations of human powers, have certain conveniences, but it is utterly unscientific, and loses sight of the great value of the study in tracing the gradual growth of our complex systems and customs from the primitive ways of our progenitors.

On the other hand, the division first indicated is as perfectly definite, logical, and scientific as any such division can be. That there are many inconveniences attending wide local disjunctions of the collections containing subjects so distinct yet so nearly allied as physical and psychical anthropology must be fully admitted; but these could only have been overcome by embracing in one grand institution the various national collections illustrating the different branches of science and art, placed in such order and juxtaposition that their mutual relations might be apparent, and the resources of each might be brought to bear upon the elucidation of all the others—an ideal institution, such as the world has not yet seen, but into which the old British Museum might at one time have been developed.

A purely "Natural History Museum" will then embrace a collection of objects illustrating the natural productions of the earth, and in its widest and truest sense should include, as far as they can be illustrated by museum specimens, all the sciences which deal with natural phenomena. It has only been the difficulties, real or imaginary, in illustrating them which have excluded such subjects as astronomy, physics, chemistry, and physiology from occupying departments in our National Natural History Museum, while allowing the introduction of their sister sciences, mineralogy, geology, botany, and zoology.

Though the experimental sciences and those which deal with the laws which govern the universe, rather than with the materials of which it is composed, have not hitherto greatly called forth the collector's instinct, or depended upon museums for their illustration, yet the great advantages of collections of the various instruments by means of which these sciences are pursued, and of examples of the methods by which they are taught, are yearly becoming more manifest. Museums of scientific apparatus now form portions of every well-equipped educational establishment, and under the auspices of the Science and Art Department at South Kensington a national collection illustrating those branches of natural history science which have escaped recognition in the British Museum is assuming a magnitude and importance which brings the question of properly housing and displaying it urgently to the front.

Anomalies such as these are certain to occur in the present almost infantile though rapidly progressive state of science. It may be taken for granted that no scientific institution of any complexity of organization can be, except at the moment of its birth, abreast of the most modern views of the subject, especially in the dividing lines between, and the proportional representation of, the various branches of knowledge which it includes.

The necessity for subdivisions in the study of science is continually becoming more apparent as the knowledge of the details of each subject multiplies without corresponding increase in the power of the human mind to grasp and deal with them, and the dividing lines not only become sharper, but as knowledge advances they frequently require revision. It might be supposed that such revision would adjust itself to the direction taken by the natural development of the relations of the different branches of science, and the truer conceptions entertained of such relations. But this is not always so. Artificial barriers are continually being raised to keep these dividing lines in the direction in which they have once started. Difficulties of readjustment arise not only from the mechanical obstacles caused by the size and arrangements of the buildings and facilities for the allocation of various kinds of collections, but still more from the numerous personal interests which grow up and wind their meshes around such institutions. Professors and curatorships of this or that division of science are founded and endowed, and their holders are usually tenacious either of encroachment upon or of any wide enlargement of the boundaries of the subject they have undertaken to teach or to illustrate; and in this way, more than any other, passing phases of scientific knowledge have become crystallized or fossilized in institutions where they might least have been expected. I may instance many European Universities and great museums in which zoology and comparative anatomy are still held to be distinct subjects taught by different professors, and where, in consequence of the division of the collections under their charge, the skin of an animal, illustrating its zoology, and its skeleton and teeth, illustrating its anatomy, must be looked for in different and perhaps remotely placed buildings.

For the perpetuation of the unfortunate separation of palæontology from biology, which is so clearly a survival of an ancient condition of scientific culture, and for the maintenance in its integrity of the heterogeneous compound of sciences which we now call "geology," the faulty organization of our museums is in a great measure responsible. The more their rearrangement can be made to overstep and break down the abrupt line of demarcation which is still almost universally drawn between beings which live now and those which have lived in past times, so deeply rooted in the popular mind and so hard to eradicate even from that of the scientific student, the better it will be for the progress of sound biological knowledge.

But it is not of the removal of such great anomalies and inconsistencies which, when they have once grown up, require heroic methods to set them right, but rather of certain minor defects in the organization of almost all existing museums which are well within the capacity of comparatively modest administrative means to remedy, that I have now to speak.

That great improvements have been lately effected in many respects in some of the museums in this country, on the Continent, and especially in America, no one can deny. The subject, as I have already indicated, is, happily, exciting the attention of those who have the direction of them, and even awakening interest in the mind of the general public. It is in the hope of in some measure helping on or guiding this movement that I have ventured on the remarks which follow.

The first consideration in establishing a museum, large or small, either in a town, institution, society, or school, is that it should have some definite object or purpose to fulfil; and the next is that means should be forthcoming not only to establish but also to maintain the museum in a suitable manner to fulfil that purpose. Some persons are enthusiastic enough to think that a museum is in itself so good an object that they have only to provide a building and cases and a certain number of specimens, no matter exactly what, to fill them, and then the thing is done; whereas the truth is the work is only then begun. What a museum really depends upon for its success and usefulness is not its building, not its cases, not even its specimens, but its curator. He and his staff are the life and soul of the institution, upon whom its whole value depends; and yet in many—I may say most—of our museums they are the last to be thought of. The care, the preservation, the naming of the specimens are either left to voluntary effort—excellent often for special collections and for a limited time, but never to be depended on as a permanent arrangement—or a grievously under-salaried and consequently uneducated official is expected to keep in order, to clean, dust, arrange, name, and display in a manner which will contribute to the advancement of scientific knowledge, collections ranging in extent over almost every branch of human learning, from the contents of an ancient British barrow to the last discovered bird of paradise from New Guinea.

Valuable specimens not unfrequently find their way into museums thus managed. Their public-spirited owners fondly imagine that they will be preserved and made of use to the world if once given to such an institution. Their fate is, unfortunately, far otherwise. Dirty, neglected, without label, their identity lost, they are often finally devoured by insects or cleared away to make room on the crowded shelves for the new donation of some fresh patron of the institution. It would be far better that such museums should never be founded. They are traps into which precious—sometimes priceless—objects fall only to be destroyed; and, what is still worse, they bring discredit on all similar institutions, make the very name of museum a byword and a reproach, hindering instead of advancing the recognition of their value as agents in the great educational movement of the age.

A museum is like a living organism—it requires continual and tender care. It must grow, or it will perish; and the cost and labour required to maintain it in a state of vitality is not yet by any means fully realized or provided for, either in our great national establishments or in our smaller local institutions.

Often as it has been said, it cannot be too often repeated, that the real objects of forming collections, of whatever kind (apart, of course, from the mere pleasure of acquisition—sometimes the only motive of private collectors), and which, although in very different degrees, and often without being recognized, underlie the organization of all museums, are two, which are quite distinct, and sometimes even conflicting. The first is to advance or increase the knowledge of some given subject. This is generally the motive of the individual collector, whose experience shows him the vast assistance in forming definite ideas in any line of research in which he may be occupied that may be derived from having the materials for its study at his own command, to hold and to handle, to examine and compare, to take up and lay aside whenever the favourable moment to do so occurs. But unless his subject is a very limited one, or his means the reverse, he soon finds the necessity of consulting collections based on a larger scale than his own. Very few people have any idea of the multiplicity of specimens required for the purpose of working out many of the simplest problems concerning the life-history of animals or plants. The naturalist has frequently to ransack all the museums, both public and private, of Europe and America in the endeavour to compose a monograph of a single common genus, or even species, that shall include all questions of its variation, changes in different seasons, and under different climates and conditions of existence, and the distribution in space and time of all its modifications. He often has to confess at the end that he has been baffled in his research for want of the requisite materials for such an undertaking. Of course this ought not to be, and the time will come when it will not be, but that time is very far off yet.

We all know the old saying that the craving for riches grows as the wealth itself increases. Something similar is true of scientific collections brought together for the purpose of advancing knowledge. The larger they are the more their deficiencies seem to become conspicuous; the more desirous we are to fill up the gaps which provokingly interfere with our extracting from them the complete story they have to tell.

Such collections are, however, only for the advanced student, the man who has already become acquainted with the elements of his science, and is in a position, by his knowledge, by his training, and by his observing and reasoning capacity, to take advantage of such material to carry on the subject to a point beyond that at which he takes it up.

But there is another and a far larger class to whom museums are or should be a powerful means of aid in acquiring knowledge. Among such those who are commencing more serious studies may be included; but I especially refer to the much more numerous class, and one which it may be hoped will year by year bear a greater relative proportion to the general population of the country, who, without having the time, the opportunities, or the abilities to make a profound study of any branch of science, yet take a general interest in its progress, and wish to possess some knowledge of the world around them and of the principal facts ascertained with regard to it, or at least some portions of it. For such persons museums may be, when well organized and arranged, of benefit to a degree that at present can scarcely be realized.

To diffuse knowledge among persons of this class is the second of the two purposes of museums of which I have spoken.

I believe that the main cause of what may be fairly termed the failure of the majority of museums—especially museums of natural history—to perform the functions that might be legitimately expected of them is that they nearly always confound together the two distinct objects which they may fulfil, and by attempting to combine both in the same exhibition practically accomplish neither.

In accordance with which of those two objects, which may be briefly called *research* and *instruction*, is the main end of the museum, so should the whole be primarily arranged; and in accordance with the object for which each specimen is required, so should it be treated.

The specimens kept for research, for advancement of knowledge, for careful investigations in structure and development, or for showing the minute distinctions which must be studied in working out the problems connected with variations of species according to age, sex, season, or locality; for fixing the limits of geographical distribution, or determining the range in geological time, must be not only exceedingly numerous (so numerous, indeed, that it is almost impossible to put a limit on what may be required for such purposes), but they must also be kept under such conditions as to admit of ready and close examination and comparison.

If the whole of the specimens really required for enlarging the boundaries of zoological or botanical science were to be displayed in such a manner that each one could be distinctly seen by any visitor sauntering through the public galleries of a museum, the vastness and expense of the institution would be quite out of all proportion to its utility; the specimens themselves would be quite inaccessible to the examination of all those capable of deriving instruction from them, and, owing to the injurious effects of continued exposure to light upon the greater number of preserved natural objects, would ultimately lose a large part of their permanent value. Collections of this kind must, in fact, be treated as the books in a library, and be used only for consultation and reference by those who are able to read and appreciate their contents. To demand, as has been ignorantly done, that all the specimens belonging to our national museums, for instance, should be displayed in cases in the public galleries, would be equivalent to asking that every book in a library, instead of being shut up and arranged on shelves for consultation when required, should have every single page framed and glazed and hung on the walls, so that the humblest visitor as he passes along the galleries has only to open his eyes and revel in the wealth of literature of all ages and all countries, without so much as applying to a custodian to open a case. Such an arrangement is perfectly conceivable. The idea from some points of view is magnificent, almost sublime. But imagine the space required for such an arrangement of the national library of books, or, indeed, of any of the smallest local libraries; imagine the inconvenience to the real student, the disadvantages which he would be under in reading the pages of any work fixed in an immovable position beneath a glass case; think of the enormous distances he would often have to traverse to compare a reference or verify a quotation, and the idea of sublimity soon gives place to its usual antithesis. The attempt to display every bird, every insect, shell, or plant, which is or ought to be in any of our great museums of reference would produce an exactly similar result.

In the arrangement of collections designed for research, which, of course, will contain all those precious specimens called "types," which must be appealed to through all time to determine the species to which a name was originally given, the principal points to be aimed at are—the preservation of the objects from all influences deleterious to them, especially dust, light, and damp; their absolutely correct identification, and record of every circumstance that need be known of their history; their classification and storage in such a manner that each one can be found without difficulty or loss of time; and, both on account of expense as well as convenience of access, they should be made to occupy as small a space as is compatible with these requirements. They should be kept in rooms provided with suitable tables and good light for their examination, and within reach of the necessary books of reference on the particular subjects which the specimens illustrate. Furthermore, the rooms should be so situated that the officers of the museum, without too great hindrance to their own work, can be at hand for occasional assistance and supervision of the student, and if collections of research and exhibited specimens are contained in one building, it is obvious that the closer the contiguity in which those of any particular group are placed the greater will be the convenience both of students and curators, for in very few establishments will it be possible to form each series on such a scale as to be entirely independent of the other.

On the other hand, in a collection arranged for the instruction of the general visitor, the conditions under which the specimens are kept should be totally different. In the first place, their numbers must be strictly limited, according to the nature of the subject to be illustrated and the space available. None must be placed too high or too low for ready examination. There must be no crowding of specimens one behind the other, every one being perfectly and distinctly seen, and with a clear space around it. Imagine a picture gallery with half the pictures on the walls partially or entirely concealed by others hung in front of them: the idea seems preposterous, and yet this is the approved arrangement of specimens in most public museums. If an object is worth putting into a gallery at all it is worth such a position as will enable it to be seen. Every specimen exhibited should be good of its kind, and all available skill and care should be spent upon its preservation and rendering it capable of teaching the lesson it is intended to convey. And here I cannot refrain from saying a word upon the sadly neglected art of taxidermy, which continues to fill the cases of most of our museums with wretched and repulsive caricatures of mammals and birds, out of all natural proportions, shrunken here and bloated there, and in attitudes absolutely impossible for the creature to have assumed while alive. Happily there may be seen occasionally, especially where amateurs of artistic taste and good knowledge of natural history have devoted themselves to the subject, examples enough—and you are fortunate in possessing them in Newcastle—to show that an animal can be converted after death, by a proper application of taxidermy, into a real life-like representation of the original, perfect in form, proportions, and attitude, and almost, if not quite, as valuable for conveying information on these points as the living creature itself. The fact is that taxidermy is an art resembling that of the painter, or rather the sculptor; it requires natural genius as well as great cultivation, and it can never be permanently improved until we have abandoned the present conventional low standard and low payment for "bird-stuffing," which is utterly inadequate to induce any man of capacity to devote himself to it as a profession.

To return from this digression, every specimen exhibited should have its definite purpose, and no absolute duplicate should on any account be permitted. Above all, the purpose for which each specimen is exhibited, and the main lesson to be derived from it, must be distinctly indicated by the labels affixed, both as headings of the various divisions of the series, and to the individual specimens. A well-arranged educational museum has been defined as a collection of instructive labels illustrated by well-selected specimens.

What is, or should be, the order of events in arranging a portion of a public museum? Not certainly, as too often happens now, bringing a number of specimens together almost by haphazard, and cramming them as closely as possible in a case far too small to hold them, and with little reference to their order or to the possibility of their being distinctly seen. First, as I said before, you must have your curator. He must carefully consider the object of the museum, the class and capacities of the persons for whose instruction it is founded, and the space available to carry out this object. He will then divide the subject to be illustrated into groups, and consider their relative proportions, according to which he will plan out the space. Large labels will next be prepared for the principal headings, as the chapters of a book, and smaller ones for the various subdivisions. Certain propositions to be illustrated, either in the structure, classification, geographical distribution, geological position, habits, or evolution of the subjects dealt with, will be laid down and reduced to definite and concise language. Lastly will come the illustrative specimens, each of which as procured and prepared will fall into its appropriate place. As it is not always easy to obtain these at the time that they are wanted, gaps will often have to be left, but these, if properly utilized by drawings or labels, may be made nearly as useful as if occupied by the actual specimens.

A public exhibition which is intended to be instructive and interesting must never be crowded. There is, indeed, no reason why it ever should be. Every such exhibition, whether on a large or small scale, can only contain a representative series of specimens, selected with a view to the needs of the particular class of persons who are likely to visit the gallery, and the number of specimens exhibited should be adapted to the space available. There is, therefore, rarely any excuse for filling it up in such a manner as to interfere with the full view of every specimen shown. A crowded gallery, except in some very exceptional circumstances, at once condemns the curator, as the remedy is generally in his own hands. In order to avoid it he has nothing to do but sternly to eliminate all the less important specimens. If any of these possess features of historical or scientific interest demanding their permanent preservation, they should be kept in the reserve collections; if otherwise, they should not be kept at all.

The ideal public museums of the future will, however, require far more exhibition space than has hitherto been allowed; for though the number of specimens shown may be fewer than is often thought necessary now, each will require more room if the conditions above described are carried out, and especially if it is thought desirable to show it in such a manner as to enable the visitor to realize something of the wonderful complexity of the adaptations which bring each species into harmonious relation with its surrounding conditions. Artistic reproductions of natural environments, illustrations of protective resemblances, or of special modes of life, all require much room for their display. This method of exhibition, wherever faithfully carried out, is, however, proving both instructive and attractive, and will doubtless be greatly extended.

Guide-books and catalogues are useful adjuncts, as being adapted to convey fuller information than labels, and as they can be taken away for study during the intervals of visits to the museum, but they can never supersede the use of labels. Anyone who is in the habit of visiting picture galleries where the names of the artists and the subject are affixed to the frame, and others in which the information has in each case to be sought by reference to a catalogue, must appreciate the vast superiority in comfort and time-saving of the former plan.

Acting upon such principles as these, every public gallery of a museum, whether the splendid saloon of a national institution or the humble room containing the local collection of a village club, can be made a centre of instruction, and will offer interests and attractions which will be looked for in vain in the majority of such institutions at the present time.

One of the best illustrations of the different treatment of collections intended for research or advancement of knowledge, and for popular instruction or diffusion of knowledge, is now to be seen in Kew Gardens, where the admirably constructed and arranged herbarium answers the first purpose, and the public museums of economic botany the second. A similar distinction is carried out in the collections of systematic botany in the natural history branch of the British Museum, with the additional advantage of close contiguity; indeed, as an example of a scheme of good museum arrangement (although not perfect yet in details), I cannot do better than refer to the upper story in the east wing of that institution. The same principles, little regarded in former times in this country, and still unknown in some of the largest Continental museums, are gradually pervading every department of the institution, which, from its national character, its metropolitan position, and exceptional resources, ought to illustrate in perfection the ideal of a natural history museum. In fact, it is only in a national institution that an exhaustive research collection in all branches of natural history, in which the specialist of every group can find his own subject fully illustrated, can or ought to be attempted.

As the actual comparison of specimen with specimen is the basis of zoological and botanical research, and as work done with imperfect materials is necessarily imperfect in itself, it is far the wisest policy to concentrate in a few great central institutions, the number and situation of which must be determined by the population and the resources of the country, all the collections, especially those containing specimens already alluded to as so dear to the systematic naturalist, known as authors' "types," required for original investigations. It is far more advantageous to the investigator to go to such a collection and take up his temporary abode there, while his research is being carried out, with all the material required at his hand at once, than to travel from place to place and pick up piecemeal the information he requires, without opportunity of direct comparison of specimens.

I do not say that collections for special study, and even original research, should not, under particular circumstances and limitations, be formed at museums other than central national institutions, or that nothing should be retained in provincial museums but what is of a directly educational or elementary nature. A local collection, illustrating the fauna and flora of the district, should be part of every such museum; and this may be carried to almost any amount of detail, and therefore in many cases it would be very unadvisable to exhibit the whole of it. A selection of the most important objects may be shown under the conditions described above, and the remainder carefully preserved in cabinets for the study of specialists.

It is also very desirable in all museums, in order that the exhibited series should be as little disturbed as possible in arrangement, and be always available for the purpose for which it is intended, that there should be, for the use of teachers and students, a supplementary set of common objects, which, if injured, could be easily replaced. It must not be forgotten that the zealous investigator and the conscientious curator are often the direst antagonists: the one endeavours to get all the knowledge he can out of a specimen, regardless of its ultimate fate, and even if his own eyes alone have the advantage of it; the other is content if a limited portion only is seen, provided that can be seen by everyone both now and hereafter.

Such, then, is the primary principle which ought to underlie the arrangement of all museums—the distinct separation of the two objects for which collections are made; the publicly exhibited collection being never a store-room or magazine, but only such as the ordinary visitor can understand and profit by, and the collection for students being so arranged as to afford every facility for examination and research. The improvements that can be made in detail in both departments are endless, and to enter further into their consideration would lead me far beyond the limits of this address. Happily, as I said before, the subject is receiving much attention.

I would willingly dwell longer upon it—indeed I feel that I have only been able to touch slightly and superficially upon many questions of practical interest, well worthy of more detailed consideration—but time warns me that I must be bringing this discourse to a close, and I have still said nothing in reference to subjects upon which you may expect some words on this occasion. I mean those great problems concerning the laws which regulate the evolution of organic beings, problems which agitate the minds of all biologists of the present day, and the solution of which is watched with keen interest by a far wider circle—a circle, in fact, coincident with the intelligence and education of the world. Several communications connected with these problems will be brought before the Sectional meetings during the next few days, and we shall have the advantage of hearing them discussed by some of those who by virtue of their special attention to and full knowledge of these subjects are most competent to speak with authority. It is therefore for me rather delicate ground to tread upon, especially at the close of a discourse mainly devoted to another question. I will, however, briefly point out the nature of the problems and the lines which the endeavour to solve them will probably take, without attempting to anticipate the details which you will doubtless hear most fully and ably stated elsewhere.

I think I may safely premise that few, if any, original workers at any branch of biology appear now to entertain serious doubt about the general truth of the doctrine that all existing forms of life have been derived from other forms by a natural process of descent with modification, and it is generally acknowledged that to the records of the past history of life upon the earth we must look for the actual confirmation of the truth of a doctrine which accords so strongly with all we know of the present history of living beings.

Prof. Huxley wrote in 1875:—"The only perfectly safe foundation for the doctrine of evolution lies in the historical, or rather archæological, evidence that particular organisms have arisen by the gradual modification of their predecessors, which is furnished by fossil remains. That evidence is daily increasing in amount and in weight, and it is to be hoped that the comparisons of the actual pedigree of these organisms with the phenomena of their development may furnish some criterion by which the validity of phylogenic conclusions deduced from the facts of embryology alone may be satisfactorily tested."

Palæontology, however, as we all know, reveals her secrets with no open hand. How can we be reminded of this more forcibly than by the discovery announced scarcely three months ago by Prof. Marsh of numerous mammalian remains from formations of the Cretaceous period, the absence of which had so long been a source of difficulty to all zoologists? What vistas does this discovery open of future possibilities, and what thorough discredit, if any were needed, does it throw on the value of negative evidence in such matters! Bearing fully in mind the necessary imperfection of the record we have to deal with, I think that no one taking an impartial survey of the recent progress of palæontological discovery can doubt that the evidence in favour of a gradual modification of living forms is still steadily increasing. Any regular progressive series of changes of structure coinciding with changes in time can of course only be expected to be preserved and to come again before our eyes under such a favourable combination of circumstances as must be of most rare occurrence; but the links, more or less perfect, of many such series are continually being revealed, and the discovery of a single intermediate form is often of immense interest as indicating the path along which the modification from one apparently distinct form to another may have taken place.

Though palæontology may be appealed to in support of the conclusion that modifications have taken place as time advanced, it can scarcely afford any help in solving the more difficult problems which still remain as to the methods by which the changes have been brought about.

Ever since the publication of what has been truly described as the "creation of modern natural history," Darwin's work on the "Origin of Species," there has been no little controversy as to how far all the modifications of living forms can be accounted for by the principle of natural selection or preservation of variations best adapted for their surrounding conditions, or whether any, and if so what, other factors have taken part in the process of organic evolution.

It certainly cannot be said that in these later times the controversy has ended. Indeed those who are acquainted with scientific literature must know that notes struck at the last annual meeting of this Association produced a series of reverberations, the echoes of which have hardly yet died away.

Within the last few months also, two important works have appeared in our country, which have placed in an accessible and popular form many of the data upon which the most prevalent views on the subject are based.

The first is, "Darwinism: an Exposition of the Theory of Natural Selection, with some of its Applications," by Alfred Russel Wallace. No one could be found so competent to give such an exposition of the theory as one who was, simultaneously with Darwin, its independent originator, but who, by the title he has chosen no less than by the contents of the book, has, with rare modesty and self-abnegation, transferred to his fellow-labourer all the merit of the discovery of what he evidently looks upon as a principle of overwhelming importance in the economy of Nature; "supreme," indeed, he says, "to an extent which even Darwin himself hesitated to claim for it."

The other work I refer to is the English translation of the remarkable "Essays upon Heredity and Kindred Biological Problems," by Dr. August Weismann, published at the Oxford Clarendon Press, in which is fully discussed the very important but still open question—a question which was brought into prominence at our meeting at Manchester two years ago—of the transmission or non-transmission to the offspring of characters acquired during the lifetime of the parent.

It is generally recognized that it is one of the main elements of Darwin's, as well as of every other theory of evolution, that there is in every individual organic being an innate tendency to vary from the standard of its predecessors, but that this tendency is usually kept under the sternest control by the opposite tendency to resemble them, a force to which the terms "heredity" and "atavism" are applied. The causes of this initial tendency to vary, as well as those of its limits and prevailing direction, and the circumstances which favour its occasional bursting through the constraining principle of heredity offer an endless field for speculation. Though several theories of variation have been suggested, I think that no one would venture to say we have passed beyond the threshold of knowledge of the subject at present.

Taking for granted, however, as we all do, that this tendency to individual variation exists, then comes the question, What are the agents by which, when it has asserted itself, it is controlled or directed in such a manner as to produce the permanent or apparently permanent modifications of organic structures which we see around us? Is "survival of the fittest" or preservation by natural selection of those variations best adapted for their surrounding conditions (the essentially Darwinian or still more essentially Wallacian doctrine) the sole or even the chief of these agents? Can isolation, or the revived Lamarckian view of the direct action of the environment, or the effects of use or disuse accumulating through generations, either singly or combined, account for all? or is it necessary to invoke the aid of any of the numerous subsidiary methods of selection which have been suggested as factors in bringing about the great result?

Anyone who has closely followed these discussions, especially those bearing most directly upon what is generally regarded as the most important factor of evolution—natural selection, or "survival of the fittest"—cannot fail to have noticed the appeal constantly made to the advantage, the utility, or otherwise of special organs, or modifications of organs or structures to their possessors. Those who have convinced themselves of the universal application of the doctrine of natural selection hold that every particular structure or modification of structure must be of utility to the animal or plant in which it occurs, or to some ancestor of that animal or plant, otherwise it could not have come into existence; the only reservation being for cases which are explained by the principle which Darwin called "correlation of growth." Thus the extreme natural selectionists and the old-fashioned school of teleologists are so far in agreement.

On the other hand, it is held by some that numerous structures and modifications of structures are met with in Nature which are manifestly useless; it is even confidently stated that there are many which are positively injurious to their possessor, and therefore could not possibly have resulted from the action of natural selection of favourable variations. Organs or modifications when in an incipient condition are especially quoted as bearing upon this difficulty. But here, it seems to me, we are continually appealing to a criterion by which to test our theories of which we know far too little, and this (though often relied upon as the strongest) is, in reality, the weakest point of the whole discussion.

Of the variations of the form and structure of organic bodies we are beginning to know something. Our museums, when more complete and better organized, will teach us much on this branch of the subject. They will show us the infinite and wonderful and apparently capricious modifications of form, colour, and of texture to which every most minute portion of the organization of the innumerable creatures which people the earth is subject. They will show us examples of marvellously complicated and delicate arrangements of organs and tissues in many of what we consider as almost the lowest and most imperfectly organized groups of beings with which we are acquainted. But as to the use of all these structures and modifications in the economy of the creatures that possess them, we know, I may almost say, nothing, and our museums will never teach us these things. If time permitted I might give numerous examples in the most familiar of all animals, whose habits and actions are matters of daily observation, with whose life-history we are as well acquainted almost as we are with our own, of structures the purposes of which are still most doubtful. There are many such even in the composition of our own bodies. How, then, can we expect to answer such questions when they relate to animals known to us only by dead specimens, or by the most transient glimpses of the living in a state of nature, or when kept under the most unnatural conditions in confinement? And yet this is actually the state of our knowledge of the vast majority of the myriads of living beings which inhabit the earth. How can we, with our limited powers of observation and limited capacity of imagination, venture to pronounce an opinion as to the fitness or unfitness for its complex surroundings of some peculiar modification of structure found in some strange animal dredged up from the abysses of the ocean, or which passes its life in the dim seclusion of some tropical forest, and into the essential conditions of whose existence we have at present no possible means of putting ourselves in any sort of relation?

How true it is that, as Sir John Lubbock says, "we find in animals complex organs of sense richly supplied with nerves, but the functions of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight; and even within the boundaries of our own senses there may be endless sounds which we cannot hear, and colours as different as red from green of which we have no conception. These and a thousand other questions remain for solution. The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of colour which we cannot see, of sensations which we cannot conceive."

The fact is that nearly all attempts to assign purposes to the varied structures of animals are the merest guesses and assumptions. The writers on natural history of the early part of the present century, who "for every why must have a wherefore," abound in these guesses, which wider knowledge shows to be untenable. Many of the arguments for or against natural selection, based upon the assumed utility or equally assumed uselessness of animal and vegetable structures, have nothing more to recommend them. In fact, to say that any part of the organization of an animal or plant, or any habit or instinct with which it is endowed, is useless, or still more injurious, seems to me an assumption which, in our present state of knowledge, we are not warranted in making. The time may come when we shall have more light, but infinite patience and infinite labour are required before we shall be in a position to speak dogmatically on these mysteries of Nature—labour not only in museums, laboratories, and dissecting-rooms, but in the homes and haunts of the animals themselves, watching and noting their ways amid their natural surroundings, by which means alone we can endeavour to penetrate the secrets of their life-history. But until that time comes, though we may not be quite tempted to echo the despairing cry of the poet, "Behold, we know not anything," a frank confession of ignorance is the most straightforward, indeed the only honest position we can assume when questioned on these subjects.

However much we may be convinced of the supreme value of scientific methods of observation and of reasoning, both as mental training of the individual and in the elucidation of truth and advancement of knowledge generally, it is impossible to be blind to the fact that we who are engaged with the investigation of those subjects which are commonly accepted as belonging to the domain of physical science are unfortunately not always, by virtue of being so occupied, possessed of that most precious gift, "a right judgment in all things."

No one intimately acquainted with the laborious and wavering steps of scientific progress (I can answer at least for one branch of it) can look upon that progress with a perfect feeling of satisfaction.

Can it be said of any of us that our observations are always accurate, the materials on which they are based always sufficient, our reasoning always sound, our conclusions always legitimate? Is there any subject, however limited, of which our knowledge can be said to have reached finality?

Or if it happens to any of us as to

> A man who looks at glass
> On it may stay his eye,
> Or if he pleases through it pass
> And then the heavens espy,

are not those heavens which are beyond the immediate objects of our observation coloured by our prejudices, prepossessions, emotions, or imagination, as often as they are defined by any profound insight into the depth of Nature's laws? In most of these questions an open mind and a suspended judgment appear to me the true scientific position, whichever way our inclinations may lead us.

For myself, I must own that when I endeavour to look beyond the glass, and frame some idea of the plan upon which all the diversity in the organic world has been brought about, I see the strongest grounds for the belief, difficult as it sometimes is in the face of the strange, incomprehensible, apparent defects in structure, and the far stranger, weird, ruthless savagery of habit, often brought to light by the study of the ways of living creatures, that natural selection, or survival of the fittest, has, among other agencies, played a most important part in the production of the present condition of the organic world, and that it is a universally acting and beneficent force continually tending towards the perfection of the individual, of the race, and of the whole living world.

I can even go further and allow my dream still thus to run:—

> Oh yet we trust that somehow good
> Will be the final goal of ill,—
>
> That nothing walks with aimless feet,
> That not one life shall be destroyed
> Or cast as rubbish to the void
> When God hath made the pile complete.

SECTION A.

MATHEMATICS AND PHYSICS.

OPENING ADDRESS BY CAPTAIN W. DE W. ABNEY, C.B., R.E., F.R.S., F.R.A.S., PRESIDENT OF THE SECTION.

THE occupant of this chair has a difficult task to perform, should he attempt to address himself to all the various subjects with which this Section is supposed to deal. I find that it has very often been the custom that some one branch of science should be touched upon by the President, and I shall, as far as in me lies, follow this procedure.

This year is the jubilee of the practical introduction of photography by Daguerre and Fox Talbot, and I have thought I might venture to take up your time with a few remarks on the effect of light on matter. I am not going into the history of photography, nor to record the rivalries that have existed in regard to the various discoveries that have been made in it. A brand-new history of photography, I dare say, would be interesting, but I am not the person to write one; and I would refer those who desire information as to facts and dates to histories which already exist. In foreign histories perhaps we English suffer from speaking and writing in a language which is not understanded of the foreign people; and the credit of several discoveries is sometimes allotted to nationalities who have no claim to them. Be that as it may, I do not propose to correct these errors or to make any reclamations. I leave that to those whose leisure is greater than mine.

I have often asserted, and I again assert, that there should be no stimulus for the study of science to be compared to photography. Step by step, as it is pursued, there will be formed a desire for a knowledge of all physical science. Physics, chemistry, optics, and mathematics are all required to enable it to be studied as it should be studied; and it has the great advantage that experimental work is the very foundation of it, and results of some kind are always visible. I perhaps am taking an optimist view of the matter, seeing there are at least 25,000 living facts against my theory, and perhaps not 1 per cent. of them in its favour. I mean that there are at least 25,000 persons who take photographs, and scarcely 1 per cent. who know or care anything of the "why or wherefoie" of the processes, so far as theory is concerned. If we call photography an applied science, it certainly has a larger number who practise it, and probably fewer theorists, than any other.

He would be a very hardy man who would claim for Nièpce, Daguerre, or Fox Talbot the discovery of photographic action on matter. The knowledge that such an action existed is probably as old as the fair-skinned races of mankind, who must have recognized the fact that light, and particularly sunlight, had a tanning action on the epidermis, and the women then, as now, no doubt took their precautions against it. As to what change the body acted upon by light underwent it need scarcely be said that nothing was known, and perhaps the first scientific experiment in this direction was made rather more than a hundred years ago by Scheele, the Swedish chemist, who found that when chloride of silver was exposed to light chlorine was given off. It was not till well in the forties that any special attention was given to the action that light had on a variety of different bodies; and then Sir John Herschel, Robert Hunt, Becquerel, Draper, and some few others carried out experiments which may be termed classical. Looking at the papers which Herschel published in the Philosophical Transactions and elsewhere, it is not too much to say that they teem with facts which support the grand principle that without the absorption of radiation no chemical action can take place on a body; in other words, we have in them experimental proofs of the law of the conservation of energy. Hunt's work, "Researches on Light," is still a text-book to which scientific photographers refer, and one is sometimes amazed at the amount of experimental data which is placed at our disposal. The conclusions that Hunt drew from his experiments, however, must be taken with caution in the light of our present knowledge, for they are often vitiated by the idea which he firmly held, that radiant heat, light, and chemical action, or actinism, were each of them properties, instead of the effects, of radiation. Again, we have to be careful in taking seriously the experiments carried out with light of various colours when such colours were produced by absorbing media. It must be remembered that an appeal to a moderately pure spectrum is the only appeal which can be legitimately made as to the action of the various components of radiation, and even then the results must be carefully weighed before any definite conclusion can be drawn. No photographic result can be considered as final unless the experiments be varied under all the conditions which may possibly arise. Coloured media are dangerous as enabling trustworthy conclusions to be drawn, unless the characters of such media have been thoroughly well tested and the light they transmit has been measured. An impure spectrum is even more dangerous to rely upon, since the access of white light would be sure to vitiate the results.

Perhaps one of the most puzzling phenomena to be met with in photography is the fact that the range of photographic action is spread over so large a portion of the spectrum. The same difficulty of course is felt in the matter of absorption, since the one is dependent on the other. Absorption by a body we are accustomed, and indeed obliged by the law of the conservation of energy, to consider as due to the transference of the energy of the ether wave-motion to the molecules and atoms comprising the body by increasing the vibrations of one or both.

In the case where chemical action takes place we can scarcely doubt that it is the atoms which in a great measure take up the energy of the radiation falling on them, as chemical action is dependent on the liberation of one or more atoms from the molecule, whilst, when the swings of the molecules are increased in amplitude, we have a rise in temperature of the body. I shall confine the few remarks I shall make on this subject to the case of chemical action. The molecule of a silver salt, such as bromide of silver, chemists are wont to look upon as composed of a limited and equal number of atoms to form the molecule. When we place a thin slab of this material before the slit of the spectroscope we find a total absorption in the violet and ultra-violet of the spectrum, and a partial absorption in the blue and green, and a diminishing absorption in the yellow and red. A photographic plate containing this same salt is acted upon in exactly the same localities and in the same relative degree as where the absorption takes place. Here, then, we have an example of, it may be, the vibrations of four atoms, one of which at least is isochronous, or partially so, with the waves composing a large part of the visible spectrum. The explanation of this is somewhat obscure. A mental picture, however, may help us. If we consider that, owing to the body acted upon being a solid, the oscillations of the molecules and atoms are confined to a limited space, it probably happens that between the times in which the atoms occupy, in regard to one another, the same relative positions, the component vibrations of, say, two of the atoms vary considerably in period. An example of what I mean is found in a pendulum formed of a bob and an elastic rod. If the bob be made to vibrate in the usual manner, and at the same time the elastic rod be elongated, it is manifest that we have a pendulum of ever-varying length. At each instant of time the period of vibration would differ from that at the next instant, if the oscillations were completed. It is manifest that increased amplitude would be given to the pendulum swings by a series of well-timed blows differing very largely in period; at the same time there would be positions of the pendulum in which some one series of well-timed blows would produce the greatest effect. In a somewhat similar manner we should imagine that the ethereal waves should produce increased amplitude in the swing of the atoms between very wide limits of period, and, further, that there should be one or more positions in the spectrum when a maximum effect is produced.[1] I would here remark that the shape of the curves of sensitiveness, when plotted graphically, of the different salts of silver to the spectrum have a marked resemblance to the graphically drawn curves of the three colour-sensations of the normal eye, as determined by Clerk Maxwell. May not the reason for the form of the one be equally applicable for the other? I only throw this out as evidence, not conclusive indeed, that the colour-sensitiveness of the eye is more probably due to a photographic action on the sensitive retina than to a merely mechanical action. That this is the case I need scarcely say has several times been propounded before.

The ease with which a silver salt is decomposed is largely, if not quite, dependent on the presence of some body which will take up some of the atoms which are thrown off from it. For instance, in chloride of silver we have a beautiful example of the necessity of such a body. In the ordinary atmosphere the chloride is, of course, coloured by the action of light; but if it be carefully dried and purified, and placed in a good vacuum, it will remain uncoloured for years in the strongest sunlight. In this case the absence of air and moisture is sufficient to prevent it discolouring.

If in the vacuum, however, a drop of mercury be introduced, the coloration by light is set up. We have the chlorine liberated from the silver and combining with the mercury vapour, and a minute film of calomel formed on the sides of the vessel.

Delicate experiments show that not only is this absorbent almost necessary when the action of light is so strong or

[1] The effect of perfect and nearly perfect synchronism of one oscillation upon another is also to be found exemplified in my "Treatise on Photography" ("Text-book of Science Series").

so prolonged that its effect is visible, but also when the exposure or intensity is so small that the effect is invisible and only to be found by development. The reason for this absorbent is not far to seek. If, for instance, silver chloride be exposed to light *in vacuo*, although the chlorine atoms may be swung off from the original molecule, yet they may only be swung off to a neighbouring molecule which has lost one of its chlorine atoms, and an interchange of atoms merely takes place. If, however, a chlorine absorbent be present which has a greater affinity for chlorine than has the silver chloride which has lost one of its atoms; then we may consider that the chlorine atoms will be on the average more absorbed by the absorbent than by the subchloride molecules. The distribution of the swung-off atoms between the absorbent and the subchloride will doubtless be directly proportional to their respective affinities for chlorine, and so for the other salts of silver. If this be so, then it will be seen that the greater the affinity of the absorbent for the halogen the more rapid will be the decomposition of the silver salt. This, then, points to the fact that if any increase in the sensitiveness of a silver salt is desired it will probably be brought about by mixing with it some stronger halogen absorbent than has yet been done.

The question as to what is the exact product of the decomposition of a silver salt by the action of light is one which has not as yet been fully answered. For my own part, I have my strong beliefs and my disbeliefs. I fully believe the first action of light to be a very simple one, though this simple action is masked by other actions taking place, due to the surroundings in which it takes place. The elimination of one atom from a molecule of a silver salt leaves the molecule in an unsatisfied condition, and capable of taking up some fresh atom. It is this capacity which seemingly shrouds the first action of light, since when exposure is prolonged the molecules take up atoms of oxygen from the air or from the moisture in it. Carey Lea, of Philadelphia, has within the last three years given some interesting experiments on the composition of what he calls the photochloride of silver, which is the chloride coloured by light, and Prof. Hodgkinson has also taken up the matter. The conclusions the former has drawn are, to my mind, scarcely yet to be accepted. According to the latter experimentalist the action of light on silver chloride is to form an oxidized subsalt. This can hardly be the case, except under certain conditions, since a coloured compound is obtained when the silver chloride is exposed in a liquid in which there is no oxygen present.

This coloration by light of the chloride of silver naturally leads our thoughts to the subject of photography in natural colours. The question is often asked when photography in natural colours will be discovered. Photography in natural colours not only has been discovered, but pictures in natural colours have been produced. I am not alluding to the pictures produced by manual work, and which have from time to time been foisted on a credulous public as being produced by the action of light itself, much to the damage of photography and usually of the so-called inventors. Roughly speaking, the method of producing the spectrum in its natural colours is to chlorinize a silver plate, expose it to white light till it assumes a violet colour, heat till it becomes rather ruddy, and expose it to a bright spectrum. The spectrum colours are then impressed in their natural tints. Experiment has shown that these colours are due to an oxidized product being formed at the red end of the spectrum and a reduced product at the violet end. Photography in natural colours, however, is only interesting from a scientific point of view, and, so far as I can see, can never have a commercial value. A process to be useful must be one by which reproductions are quickly made ; in other words, it must be a developing and not a printing process, and it must be taken in the camera, for any printing process requires not only a bright light but also a prolonged exposure. Now it can be conceived that in a substance which absorbs all the visible spectrum the molecules can be so shaken and sifted by the different rays that eventually they sort themselves into masses which reflect the particular rays by which they are shaken ; but it is almost—I might say, quite—impossible to believe that when this sifting has only been commenced, as it would be in the short exposure to which a camera picture is submitted, the substance deposited to build up the image by purely chemical means would be so obliging as to deposit in that the particular size of particle which should give to the image the colour of the nucleus on which it was depositing. I am aware that in the early days of photography we heard a good deal about curious results that had been obtained in negatives, where red brick houses were shown as red and the blue sky as bluish. The cause of these few coincidences is not hard to explain, and would be exactly the same as when the red brick houses were shown as bluish and the sky as red in a negative. The records of the production of the latter negatives are naturally not abundant, since they would not attract much attention. I may repeat, then, that photography in natural colours by a printing-out process—by which I mean by the action of light alone—is not only possible but has been done, but that the production of a negative in natural colours from which prints in natural colours might be produced appears, in the present state of our knowledge, to be impossible. Supposing it were not impracticable, it would be unsatisfactory, as the light with which the picture was impressed would be very different from that in which it would be viewed. Artists are fully aware of this difficulty in painting, and take their precautions against it.

The nearest approach to success in producing coloured pictures by light alone is the method of taking three negatives of the same subject through different-coloured glasses, complementary to the three colour-sensations which together give to the eye the sensations of white light. The method is open to objection on account of the impure colour of the glasses used. If a device could be adopted whereby only those three parts of the spectrum could be severally used which form the colour-sensations, the method would be more perfect than it is at present. Even then perfection could not be attained, owing to a defect which is inherent in photography, and which cannot be eliminated. This defect is the imperfect representation of gradation of tone. For instance, if we have a strip graduated from what we call black to white (it must be recollected that no tone can scientifically be called black, and none white) and photograph it, we shall find that in a print from the negative the darkness which is supposed to represent a grey of equal mixtures of black and white by no means does so unless the black is not as black nor the white as white as the original. The cause of this untruthfulness in photography has occupied my attention for several years, and it has been my endeavour to find out some law which will give us the density of a silver deposit on a negative corresponding with the intensity of the light acting. I am glad to say that at the beginning of this year a law disclosed itself, and I find that the transparency of a silver deposit caused by development can be put into the form of the law of error.

This law can be scarcely empiric, though at first sight it appears that the manipulations in photography are so loose that it should be so. It is this very looseness, however, which shows that the law is applicable, since in all cases I have tried it is obeyed. That there are theoretical difficulties cannot be denied, but it is believed that strictly theoretical reasoning will eventually reconcile theory with observation.

This want of truth in photography in rendering gradation, then, puts it out of the range of possibility that photography in natural colours can ever be exact, or that the three negatives system can ever get over the difficulty.

One of the reproaches that in early days was cast at photography was its inability to render colour in its proper monochromatic luminosity. Thus whilst a dark blue was rendered as white in a print—that is, gave a dense deposit in a negative—bright yellow was rendered as black in a print, or nearly so—that is, as transparent or nearly transparent glass in the negative. To the eye the yellow might be far more luminous than the blue, but the luminosity was in the photograph reversed. I need scarcely say that the reason of this want of truth in the photograph is due to the want of sensitiveness of the ordinarily used silver salts to the least refrangible end of the spectrum. Some fifteen years ago Dr. H. W. Vogel announced the fact that when silver salts were stained with certain dyes they became sensitive to the colour of the spectrum, which the dyes absorbed. This at once opened up possibilities, which, however, were not at once realized, owing perhaps to the length of exposure required when the collodion process was employed. Shortly after the gelatine process was perfected, the same dyes were applied to plates prepared by this method, which, although they contained the same silver salts as the old collodion process, yet *per se* were very much more sensitive. A new era then dawned for what has been termed isochromatic and orthochromatic photography. The dyes principally used are those belonging to the eosin group and cyanine—not the ordinary cyanine dye of commerce, but that discovered by Greville Williams. For a dye to be of use in this manner it may be taken as an axiom—first propounded by the speaker, it is believed—that it must be fugitive, or that it must be capable of forming a silver compound. The more stable a dye is the less effective it is. If we take as an example cyanine, we find that it absorbs in the orange and slightly in the red. If paper or collodion stained with this colouring-matter be exposed to the action of the spectrum, it will be found that the dye bleaches in exactly the same part of the spectrum as that in which it absorbs, following, indeed, the universal law I have already alluded to. If a film containing a silver salt be dyed with the same, it will be found that, whilst the spectrum acts on it in the usual manner—viz. darkening it in the blue, violet, and ultra-violet—the colour is discharged where the dye absorbs, showing that in one part of the spectrum it is the silver salt which is sensitive, and that in the other it is the colouring-matter. If such a plate, after exposure to the spectrum, be developed, it will be found that at both parts a deposit of silver takes place; and further, when the experiment is carefully conducted, if a plate with merely cyanine-coloured collodion be exposed to the spectrum and bleached in the orange, and after removal to the dark room another film containing a silver salt be applied and then a developer, a deposit of silver will take place where the bleaching has occurred. This points to the fact that the molecules of a fugitive dye, when altered by light, are unsatisfied, and are ready to take up an atom or atoms of silver, and other molecules of silver will deposit on such nuclei by an action which has various names in physical science, but which I do not care to mention. This is the theory which I have always advocated, viz. that the dye by its reduction acts as a nucleus on which a deposit of silver can take place. It met with opposition; a rival theory which makes the dye an "optical sensitizer"—an expression which is capable of a meaning which I conceive contrary to physical laws—being run against it. The objection to what I may call the nucleus theory is less vigorous than it has been, and its diminution is due perhaps to the more perfect understanding of the meaning of each other by those engaged in the controversy. To my mind, the action of light on fugitive dyes is one of the most interesting in the whole realm of photography, as eventually it must teach us something as to the structure of molecules, and add to the methods by which their coarseness may be ascertained. Be the theory what it may, however, a definite result has been attained, and it is now possible to obtain a *fair* representation of the luminosity of colours by means of dyed films. At present the employment of coloured screens in front of the lens, or on the lens itself, is almost an essential in the method when daylight is employed, but not till some dye is discovered which shall make a film equally sensitive for the same luminosity to the whole visible spectrum will it be possible to make orthochromatic photography as perfect as it can be made. The very fact that no photograph of even a black and white gradation will render the latter correctly must of necessity render any process imperfect, and hence in the above sentence I have used the expression "as perfect as it can be made."

The delineation of the spectrum is one of the chief scientific applications to which photography has been put. From very early days the violet and ultra-violet end of the spectrum have been favourite objects for the photographic plate. To secure the yellow and red of the spectrum was, however, till of late years, a matter of apparently insurmountable difficulty; whilst a knowledge of that part of the spectrum which lies below the red was only to be gained by its heating effect. The introduction of the gelatine process enabled the green portion of the spectrum to impress itself on the sensitive surface; whilst the addition of various dyes, as before mentioned, allowed the yellow, the orange, and a portion of the red rays to become photographic rays. Some eight years ago it was my own good fortune to make the dark infra-red rays impress themselves on a plate. This last has been too much a specialty of my own, although full explanations have been given of the methods employed. By preparing a bromide of silver salt in a peculiar manner one is able so to modify the molecular arrangement of the atoms that they answer to the swings of those waves which give rise to these radiations. By employing this salt of silver in a film of collodion or gelatine the invisible part of the spectrum can be photographed and the images of bodies which are heated to less than red heat may be caused to impress themselves upon the sensitive plate. The greatest wave-length of the spectrum to which this salt is sensitive so far is 22,000 λ, or five times the length of the visible spectrum. The exposure for such a wave-length is very prolonged, but down to a wave-length of 12,000 it is comparatively short, though not so short as that required for the blue rays to impress themselves on a collodion plate. The colour of the sensitive salt is a green blue by transmitted light; it has yet to be determined whether this colour is all due to the coarseness of the particles or to the absorption by the molecules. The fact that a film can be prepared which by transmitted light is yellow, and which may be indicative of colour due to fine particles, together with an absorption of the red and orange, points to the green colour being probably due to absorption by the molecules. We have thus in photography a means of recording phenomena in the spectrum from the ultra-violet to a very large wave-length in the infra-red—a power which physicists may some day turn to account. It would, for instance, be a research worth pursuing to photograph the heavens on a plate prepared with such a salt, and search for stars which are nearly dead or newly born, for in both cases the temperature at which they are may be such as to render them below red heat, and therefore invisible to the eye in the telescope. It would be a supplementary work to that being carried out by the brothers Henri, Common, Roberts, Gill, and others, who are busy securing photographic charts of the heavens in a manner which is beyond praise.

There is one other recent advance which has been made in scientific photography to which I may be permitted to allude, viz. that from being merely a qualitative recorder of the action of light it can now be used for quantitative measurement. I am not now alluding to photographic actinometers, such as have been brought to such a state of perfection by Roscoe; but what I allude to is the measurement and interpretation of the density of deposit in a negative. By making exposures of different lengths to a standard light, or to different known intensities of light, on the same plate on which a negative has to be taken, the photographic values of the light acting to produce the densities on the different parts of the developed image can be readily found. Indeed, by making only two different exposures to the same light, or two exposures to two different intensities of light, and applying the law of density of deposit in regard to them, a curve is readily made from which the intensities of light necessary to give the different densities of deposit in the image impressed on the same plate can be read off. The application of such scales of density to astronomical photographs, for example, cannot but be of the highest interest, and will render the records so made many times more valuable than they have hitherto been. I am informed that the United States astronomers have already adopted the use of such scales, which for the last three years I have advocated, and it may be expected that we shall have results from such scaled photographs which will give us information which would before have been scarcely hoped for.

One word as to a problem which we may say is as yet only qualitatively and not quantitatively solved. I refer to the interchangeability of length of exposure for intensity of light. Put it in this way. Suppose that with a strong light, L, a short exposure, E, be given, a chemical change, C, is obtained: will the same change, C, be obtained if the time is only an *n*th of the light L, but *n* times the exposure? Now this is a very important point, more particularly when the body acted upon is fairly stable, as, for instance, some of the water-colour pigments, which are known to fade in sunshine, but might not be supposed to do so in the light of an ordinary room, even with prolonged exposure. Many experiments have been made at South Kensington as regards this, more especially with the salts of silver, and it is found that, for any ordinary light, intensity and exposure are interchangeable, but that when the intensity of light is very feeble, say the $\frac{1}{1000000}$ of ordinary daylight, the exposure has to be rather more prolonged than it should be, supposing the exact interchangeability always held good; but it has never been found that a light was so feeble that no action could take place. Of course it must be borne in mind that the stability of the substance acted upon may have some effect; but the same results were obtained with matter which is vastly more stable than the ordinary silver salts. It may be said in truth that almost all matter which is not elemental is, in time and to some degree, acted upon by light.

I should like to have said something regarding the action of light on the iron and chromium salts, and so introduced the subject of platinotype and carbon printing, the former of which is creating a revolution in the production of artistic prints. I have, however, refrained from so doing, as I felt that the President of

Section A should not be mistaken as the President of Section B. Photogravure and the kindred processes were also inviting subjects on which to dwell, more especially as at least one of them is based on the use of the same material as that on which the first camera picture was taken by Nièpce. Again, a dread of trenching on the domains of art restrains me.

Indeed, it would have been almost impossible, and certainly impolitic, in the time which an address should occupy, to have entered into the many branches of science and art which photography covers. I have tried to confine myself to some few advances that have been made in its theory and practice.

The discovery of the action of light on silver salts is one of the marvels of this century, and it is difficult to overrate the bearing it has had on the progress of science, more especially physical science. The discovery of telegraphy took place in the present reign, and two years later photography was practically introduced; and no two discoveries have had a more marked influence on mankind. Telegraphy, however, has had an advantage over photography in the scientific progress that it has made, in that electrical currents are subject to exact measurement, and that empiricism has no place with it. Photography, on the other hand, has laboured under the disadvantage that, though it is subject to measurement, the factors of exactitude have been hitherto absent. In photography we have to deal with molecules the equilibrium of whose components is more or less indifferent according to the process used; again, the light employed is such a varying factor that it is difficult to compare results. Perhaps more than any other disadvantage it labours under is that due to quackery of the worst description at the hands of some of its followers, who not only are self-asserting, but often ignorant of the very first principles of scientific investigation. Photography deserves to have followers of the highest scientific calibre; and if only some few more real physicists and chemists could be induced to unbend their minds and study the theory of an applied science which they often use for record or for pleasure, we might hope for some greater advance than has hitherto been possible.

Photography has been called the handmaid of Art; I venture to think it is even more so the handmaid of Science, and each step taken in perfecting it will render it more worthy of snch a title.

SECTION B.

CHEMISTRY.

Opening Address by Sir Lowthian Bell, Bart., F.R.S., F.C.S., D.C.L., M.Inst.C.E., President of the Section.

It has occasionally been the practice of former occupants of this chair to devote a considerable portion of the Presidential address to the more recent discoveries in chemical science. This branch of learning advances now with such rapid strides and covers so wide a field, that no one who has not made it the business of his life can hope to discharge this duty with even a moderate share of success.

My immediate predecessor, indeed, discouraged any further attempts in this direction on the ground of the impossibility of doing it justice within the limits of a short discourse, and his remarks were consequently directed to the best methods of teaching the science with which Section B is more directly concerned. I propose this morning to add my testimony to the importance of Dr. Tilden's recommendation by comparing the rate of progress of one of our great national industries as it has been advanced with and without the aid which chemistry is capable of affording. For this purpose I have selected the metallurgy of iron, not only from my greater familiarity with its details, but because, in my judgment, it affords a suitable example for the object I have in view.

It is needless to insist on the disadvantage attending the application of a science to practical work, without a fair knowledge of the principles which regulate its action. At the same time it would be unfair to those who were engaged in the manufacture of iron during the first half of the present century to deny the value of the services rendered to their art, without giving much thought to the laws of Nature upon which their processes depended. The work so performed sufficed nevertheless to place the world in possession of the metal in such abundance and at so low a cost, that no engineering works have been delayed on account of the high price of or absence of the required quality in the produce of our ironworks during the period in question. On the other hand, it is not to be denied that since the ironmasters have allied themselves with the chemist, they have made more progress in thirty years than their predecessors did in three centuries.

No one unacquainted with the archæology of the iron trade could suppose that the colossal furnaces pouring forth their streams of molten metal, followed by the rapid action of the Bessemer converter, were the modern representatives of the iron-making appliances of former days. Out of the latter, in a low hearth not larger than a domestic fire-place, often dependent on the wind for their blast, a few pounds of ore were, at a considerable cost for labour, fuel, and waste of metal, converted into malleable iron. By means of a modern furnace in an hour and a half a ten-ton converter can be filled with liquid cast iron, which in twenty minutes may be run into ingots cheaper, stronger, and more malleable than the best wrought iron of our ancestors, or indeed of our own manufacture.

How out of the small fire of the ancient ironworks the German *Stück-Ofen* was evolved is a matter of conjecture. In both, owing to the conditions under which the fuel was burnt, carbon dioxide was largely the product of its combustion. The oxidizing property of this gas was in each the cause of the waste of metal just spoken of. Probably, and for other reasons than avoiding this loss of iron, attempts were made to increase the dimensions of the *Stück-Ofen*. If this addition were one of limited extent, the smelter would find to his cost that a substance was obtained which no longer possessed the malleable property of that obtained from the lesser furnace. This change would be due to the absorption of carbon, but not in sufficient quantity to constitute that valuable form of the metal known as cast iron. With a material useless for the smith and incapable from its difficult fusibility of being run into moulds, we can understand the delay which took place in the introduction of the blast furnace, which about the middle of the sixteenth century gave to cast iron a recognized and valuable position in the arts.

In those days there was no very exact science to appeal to, for two hundred and fifty years after the "high furnace" of the Germans and French had been set to work, Fourcroy, in his "General System of Chemical Knowledge and its Application to the Phenomena of Science and Art," arrived at the conclusion that cast metal was erroneously supposed to be a mixture of slag and iron or a compound of arsenic or manganese and iron. This was written in 1804, in a work of 5000 pages, when he leant to the opinion that Monge and Berthollet were more correct in considering the product of the blast furnace as consisting of iron, oxygen, and carbon.

When the malleable iron-maker had placed in his hands a material containing, as the pig did, more than 90 per cent. of metal, he found it greatly to his advantage to avoid having to deal with all the earthy matter contained in the ores, for it was the presence of silica and alumina which helped to add to the waste incurred in the old hearths. The object sought for in the old Catalan fires, as they were called, in treating ore was one of a reducing or deoxidizing character, whereas the reverse of this was required when ore was replaced by pig-iron. In the first oxygen had to be removed from the oxide of iron, in the latter oxygen had to be united with the metalloids found in the pig. These were distinctions unknown in the days we are considering, and therefore did not trouble the minds of the ironmasters. In both cases there was a large formation of oxide of iron, and when pig-iron was handed over to the Catalan furnace man, it was the oxide of iron so generated which performed the desired duty, and thus this simple mode of procuring malleable iron remained undisturbed for upwards of two hundred years.

The discovery which led to the discontinuance of the low blast furnace as a means of procuring iron in its malleable form was that of puddling made by Cort in 1784. In point of fact Cort's process was merely doing in a reverberatory furnace that which was previously effected by means of compressed air. In an economic point of view, however, the difference is great, and its consequences were of immense importance, for to the puddling furnace we were first indebted for an ample supply of cheap iron by which, in a variety of well-known ways, the interests of the human race have been so largely promoted. As an indication of the indifference of those formerly engaged in industrial pursuits to the scientific aspect of their calling, may be mentioned the fact that puddling had been largely followed for upwards of half a century before it occurred to anyone to examine the chemistry of the process.

Down to the beginning of the seventeenth century the only fuel used in the blast furnace, and, indeed, in the manufacture of iron generally, was charcoal. In 1620, Dudley made several attempts to substitute mineral coal for vegetable fuel in his smelting works, which, by the exhaustion of timber, had become very expensive. He failed in this, and in consequence the British iron trade gradually fell until it was not equal to the production of one modern blast furnace. This happened in 1740, when Darby, by treating pit coal in the same fashion as the charcoal burners had done with wood, *i.e.* by charring it, restored vitality to an expiring industry. It is true the restoration must have been of a languid character, for in half a century afterwards it is said the weekly produce of a furnace did not exceed fifteen or sixteen tons.

Various changes were introduced into the manufacture of iron in the first quarter of the present century, but these were rather of a mechanical than of a chemical nature. They chiefly owed their origin to the lessons taught by the chemist Black to James Watt, who profited by them in the application of steam as a motive power. This brings us to the year 1828, a year which will always be distinguished in the annals of the iron trade by the discovery of Neilson of the value of heated air in smelting the ores of this metal. I never heard it pretended that the inventor had any pretensions to be considered a man of sciencee Had it been otherwise, the knowledge of the virtues of the hot blast might have been indefinitely postponed, and this opinion is founded on the fact that for many a long year no satisfactory explanation was given why heat obtained by burning coal in the hot air apparatus was capable of saving three or four times its weight in the fuel consumed in the furnace itself. I propose, with your permission, to consider this subject with more attention than I shall devote to other portions of this address, and I am led to do this, not only because it is one of some scientific interest, but because its study seems to afford a solution to some questions in respect to which great differences of opinion prevailed among those whose daily work led them to pay much attention to their details. These questions have all a reference to the quantity of fuel consumed in smelting the ore, as this may be affected by the temperature of the blast and the dimensions of the furnaces employed for this purpose.

As is well understood, the heat excited in an iron furnace may be classified under three heads :—

First, that derived from the combustion of the coke at the point where the blast enters the furnace, the ultimate product being carbonic oxide.

Second, the conversion of a portion of this carbonic oxide into carbon dioxide.

Third, the heat carried into the furnace by the blast.

For the better illustration of the relations which the heat derived from these sources bear to each other, a table (No. I.) has been prepared in which the quantities of each are given in Centigrade calories, and reckoned upon 20 units of iron to correspond with English weights. The information upon which the calculations are based is derived from actual observation gathered from furnaces of different sizes and fed with air at different temperatures.

TABLE I.

—	A	—	—	—
Height of furnace in feet ...	48	48	80	80
Calories—per unit of coke burnt to CO ...	2078	2028	2018	2045
,, from portion of this CO burnt to CO_2 ...	560	1059	1636	1463
Total calories from coke ...	2638	3087	3654	3508
Calories in blast ...	—	508	534	732
Total heat per unit of coke ...	2638	3595	4188	4240
Temperature of blast C ...	0°	485°	485°	695°
Cwts. blast per ton of metal ...	228	128	103	94
,, escaping gases per ton of metal ...	285	170	138	126
,, slag per ton of metal ...	34	31	29	28

A second table contains statements showing the manner in which the heat so generated is appropriated in the various divisions of the duty the furnaces had to perform, and for facility of comparison, alongside the quantities of heat so required, their equivalents in the coke used have been added.

In the table No. II. the appropriation of the heat is separated into *Constants* and *Variables*. The first consists of items where the quantity of heat in making a particular quality of iron is only liable to alterations of trifling amount. On the other hand, the variables exhibit in A and B differences so considerable that work which in the furnace blown with cold air absorbed 73,388 calories per 20 cwts. of pig-iron, was done with 58,645 calories by merely raising the blast to 485°.

The cause of this great variation in the amount of heat required for a given weight of pig-iron, produced under different circumstances as to temperature of blast and size of furnace, depends on changes in the actual amount of work to be performed. How this arises will be best seen in the description of the four examples set forth in the two tables.

Beginning with A, which is a furnace 48 feet in height, blown with cold air and consuming 45 cwts. of coke and 18 cwts. of limestone per ton of metal, the volume of gas produced may be taken at 14,460 cubic yards at ordinary temperatures and pressures. At the temperature at which they escape we may assume the volume per ton of iron to be about 36,000 cubic yards, passing out of the furnace at the rate of 357 cubic yards per minute.

In comparing the consumption of coal formerly burnt in the hot-air stoves with the saving of coke in the furnace, account must be taken of the different conditions of the combustion. In Table I., owing to the small quantity of carbon dioxide formed, the heat evolved is only 2638 calories per unit of coke, whereas each unit of the coal consumed in heating the air afforded three times this quantity of heat. Doubtless there was a great loss in the operation of heating the air, for it would not appear that much above one-fourth of the theoretical quantity of heat capable of being generated by the coal reached the furnace through the *tuyères*.

We have now to consider the nature of the change which is effected in a furnace where, for every 2638 calories generated by the combustion of the coke, 508 calories are carried in by the blast. It will be readily understood that with the velocity at which the gases are passing out of the cold-blast furnace they have but little time to impart their heat to the incoming solids, or to have the carbonic oxide they contain converted into carbon dioxide. The withdrawal of so much coke, and its place taken by heat contained in the blast, means that the 14,460 cubic yards of escaping gases are reduced to about 12,120 cubic yards. The effect of this is not only to alter the speed at which the gases are passing through the materials, but to alter the relation in point of quantity which the ironstone present in the furnace bears to the coke, so that, in point of fact, a larger space is occupied by the ore than was before, and a lesser one by the fuel. We have thus the carbonic oxide passing more slowly over the oxide of iron at the same time that there is a greater quantity of the oxide exposed to the influence of the reducing gas. To illustrate how this operates, a table has been prepared, showing how each 1000 cubic feet of furnace space is occupied in the four cases we are considering :—

	A 48-feet cold blast.	B 48-feet hot blast.	C 80-feet blast.	D 80-feet blast.
Coke cubic feet ...	736	686	590	590
Limestone ,, ...	63	75	86	77
Ironstone ,, ...	201	239	324	333
	1000	1000	1000	1000

The immediate effect of the introduction of the hot blast is to alter the spaces filled by the three minerals from those given in

Column A to coke 686, limestone 75, and ore 239 cubic feet. This is followed by a twofold advantage. Volume for volume, ore and limestone possess double the heat-intercepting power of coke, and there is 19 per cent. more ore ready to oxidize the carbonic oxide passing over it at a reduced speed of 16 per cent. than there was when using cold air. The increased efficiency of the coke, due to a more perfect cooling of the gases and higher oxidation of the carbonic oxide, permits its further suppression until the relative spaces filled by the materials are those shown under Column B. These advantages would not of themselves suffice to save 16 cwts. of coke or thereabouts out of 45 cwts., but the reduction in the coke consumed is followed by a diminution in the quantity of air used and in the weight of gases and slag produced. A reference to the appropriation of heat classified under the head of "Variables" will show in consequence diminution from 73,338 to 54,643 calories.

It may be asked whether this prolonged exposure of the ore to the reducing gases could not be secured by driving the furnace at a slower speed. There is, however, a point which may be regarded as one of equilibrium, in which the quantity of cold materials charged at the top just suffices to reduce the temperature of the gases, leaving it as far as is possible consistent with the dimensions of the furnace. If the volume of blast entering at the *tuyères* is lowered one-half, it would mean that the materials would be exposed for twice the time to the hot gases that they were previous to the alteration in the rate of driving. The elevation in the temperature of the coke would enable its carbon to act on the carbon dioxide, so that there would ensue as great a loss under the second head of heat evolution in Table I. as there is gained by a more perfect interception of the heat contained in the gases.

There is, however, another way of securing this prolonged exposure of the ore to the action of the reducing gas without incurring the inconvenience just referred to, viz. by increasing the dimensions of the furnace blown with cold air. When this was done by raising the height from 48 to 71 feet, it was found that the duty performed by the coke, apart from the heat contained in the blast, was just about the same as that in the hot-blast furnace.

TABLE II.—*Showing the appropriation of Heat and its equivalent per ton Iron.*

Appropriation of Heat per 20 of Pig-Iron.	A—Blast 0° C.		B—Blast 485° C.		C—Blast 485° C.		D—Blast 695° C.	
	Calories.	Cwts. coke	Calories.	Cwts. coke	Calories.	Cwts. coke	Calories.	Cwts. coke
CONSTANTS :—								
Reduction of Fe_2O_3 in ore	33,108	12·550	33,108	9·209	33,108	7·905	33,108	7·808
Reduction of metalloids in pig	4,174	1·582	4,174	1·161	4,174	0·996	4,174	0·984
Dissociation of CO($2CO = C + CO_2$)	1,440	0·546	1,440	0·400	1,440	0·344	1,440	0·340
Fusion of pig-iron	6,600	2·501	6,600	1·836	6,600	1·576	6,600	1·557
Constant calories per 20 of pig	45,322	—	45,322	—	45,322	—	45,322	—
Coke consumed per 20 of pig ... ... cwts.	—	17·179	—	12·606	—	10·821	—	10·689
VARIABLES :—								
Evaporation of water in coke	630	0·239	411	0·114	312	0·074	298	0·070
Decomposition of water in blast	5,420	2·055	3,348	0·931	2,720	0·649	2,408	0·568
Expulsion of CO_2 in limestone	6,660	2·526	5,920	1·647	5,054	1·207	4,070	0·961
Reduction of CO_2 in limestone to CO	6,912	2·620	6,144	1·709	5,248	1·254	4,099	0·962
Fusion of slag	18,590	7·045	17,325	4·819	16,720	3·993	15,565	3·673
Carried off in escaping gases	29,482	11·178	18,486	5·144	11,043	2·636	8,906	2·101
Heat in *tuyère* water at hot-blast furnaces, loss from walls, &c.	5,694	2·158	7,011	1·950	7,057	1·686	9,389	2·616
Variables for 20 of pig	73,388	—	58,645	—	48,154	—	44,735	—
Variables for coke for 20 of pig ... ... cwts.	—	27·821	—	16·314	—	11·499	—	10·551
SUM OF CONSTANTS AND VARIABLES :—								
Calories for 20 of pig-iron	118,710	—	103,967	—	93,476	—	90,057	—
Cwts. of coke for 20 of pig-iron	—	45·000	—	28·92	—	22·32	—	21·24

With regard to the position of equilibrium above referred to, it is worthy of remark that, while this was reached when a furnace of 48 feet ran 100 tons per week when driven with cold air, it was not arrived at in one of similar dimensions using heated air until the make was increased to about 220 tons.

When we proceed to examine the composition and weight of the gases given off by a 48-feet furnace blown with air at 485° C., it will be found that about 20 per cent. of the carbon as dioxide has disappeared, due no doubt to the still excessive temperature of the upper zone and too rapid a current of the reducing agent. An obvious way to remedy this evil would be by an addition to the capacity of the furnaces. This was done by raising them to a height of 80 feet, with a cubical space three or four times greater than those of 48 feet. In such a furnace, almost the full theoretical quantity of carbon as dioxide has been obtained, but, while the larger furnace held three or four times as much ore, &c., the production was only about double that of the lesser. On referring to Table II., it will be seen that a further economy of 6·6 cwts. of coke has been effected in Furnace C as compared with B, due solely to an enlargement of space, for the temperature of the blast was exactly the same in both. This improvement, it will also be perceived, is due to an extension of those causes which acted so beneficially when hot air was applied to B.

If 6·6 cwts. of carbon or thereabouts is the full quantity per ton of iron which can be found in the gases as dioxide, and if, in a furnace working under the conditions of C, it requires 22·32 of coke to furnish this carbon and that in the carbonic oxide, it is clear we cannot withdraw any coke without disturbing the position of equilibrium supposed to have been established in the case of the furnace in question. Suppose into such a furnace the blast, instead of 485°, is admitted at 695°, as happened under Column D. The additional heat, 732 calories, instead of 534 as in C, will make itself felt throughout the entire height of the furnace, including, of course, the upper zone. Immediately this happens, the carbon dioxide generated by the reduction of the ore attacks the coke and escapes as carbonic oxide. If Table I. is examined, it will be seen that almost the whole of the additional heat carried into the furnace D, as compared with C, has been absorbed by the disappearance of carbon dioxide, so that the net power of the coke unit in both cases is practically the same. Nevertheless it will be remarked that there is still a small saving of coke due to a reduced amount of blast, escaping gases, &c.

From what has preceded, it has been concluded that a furnace of 80 feet affords sufficient opportunity for the gases being as fully saturated with oxygen as the nature of the process of deoxidizing the ore will permit. The sensible heat in the escaping gases, however, still represents a considerable loss, reduced as they have been from 29,482 to 11,043 calories.

According to estimate, it was believed that the reduction of oxide of iron ought to be attended by an increase of temperature—in other words, the conversion of carbonic oxide into carbonic dioxide produced more heat than that absorbed by splitting up oxide of iron into its constituent parts. The estimated difference not being a large one, an experiment was made by substituting in the furnace inert substances having about the same specific heat as the ore. The results confirmed the correctness of the calculation—the temperature of the escaping gases fell, and rose to their normal point when the use of ore was recommenced. A more expensive experiment was subsequently made in the same direction by building, at Ferry Hill, a pair of furnaces having a height of 103 feet, without any substantial benefit being derived from the large additional expenditure incurred.

It was Scheerer, I think, who first divided the blast furnace into zones. The first division, beginning at the top and extending twelve feet downwards, was designated the preheating zone, the following eighteen feet downwards was distinguished as the reducing zone, the next eight feet the carburizing zone, followed by four feet which constituted the zone of fusion. The lowest of all, having a depth of about six feet, was named the zone of combustion. The author of this mapping out, as it were, of the interior of the furnace, does not wish to be understood as confining its various functions within the respective spaces assigned to them; on the contrary, he admits the existence of considerable variations of position. My own observations, however, have led me to conclusions varying considerably from those adopted by Scheerer.

The fundamental cause of these differences seems to depend on the temperature considered as being required for a commencement of the reduction of the ore. By Scheerer the reducing zone is considered to require a temperature of 1000° to 1200° C. This change undoubtedly is not the same with all kinds of ores, but my experiments were conducted when using almost every variety of the mineral. According to the trials made, a mixture of one volume of carbon dioxide and two volumes of carbonic oxide at a temperature of 410°, removed 10 per cent. only of the oxygen in Cleveland ore, and 37·8 per cent. from an artificially prepared oxide. The composition of the gases at the different depths, however, indicates in an unmistakable manner the nature of the action which is going on at any particular point. A table has been prepared from actual analyses of the gases which gives the quantity of oxygen present for every 1000 parts of metal produced; and to this is added the weight of carbon they contained. The results vary, but the general inference to be drawn from the observations made on furnaces of 80 feet, is that by the time the minerals have passed through a space of eight feet of the depth they have to travel, all the oxygen susceptible of removal from the ore in the upper region is found in the gases, the remainder being retained until it reaches the zone of fusion. The same is the order of action in a somewhat modified form which was found to prevail in the case of furnaces 48 feet in height.

TABLE III.—*Showing the quantity of Oxygen and Carbon in gases per* 1000 *parts of pig-iron produced. The 8 feet immediately below charging plates is occupied by charging apparatus.*

Distance below top of minerals.	0 feet.		8½ feet.		18 feet.		31 feet.		44¼ feet.		57 feet.		62½ feet.		68 feet.	
	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.
No. 1. Oxygen ...	1843	—	1250	—	1235	—	1234	—	1236	—	1207	—	1137	—	1348	—
Carbon ...	—	1101	—	864	—	816	—	871	—	904	—	899	—	890	—	967
No. 2. Oxygen ...	1843	—	—	—	1410	—	1482	—	1190	—	1207	—	1255	—	1366	—
Carbon ...	—	1104	—	—	—	914	—	1046	—	894	—	887	—	—	—	927
No. 3. Oxygen ...	1670	—	1309	—	1206	—	1312	—	1256	—	1253	—	1253	—	1378	—
Carbon ...	—	1048	—	926	—	907	—	918	—	946	—	931	—	939	—	1013
No. 4. Oxygen ...	1670	—	1271	—	1224	—	1300	—	—	—	1261	—	1285	—	1387	—
Carbon ...	—	1048	—	897	—	898	—	917	—	—	—	926	—	977	—	1021

NOTE.—Nos. 3 and 4 were using partially calcined limestone, hence the deficiency of O and C until the lower depths are reached.

On casting the eye along the lines of figures a somewhat remarkable circumstance is apparent, viz. that the quantity of oxygen per 1000 of pig-iron gradually decreases as the gases ascend, until they approach the upper region, when it commences to increase. This had been the subject of observation for many years without any complete explanation being given of its cause. Dr. Percy, among others, bestowed some attention to the circumstance without arriving at any opinion satisfactory to himself. It is a little extraordinary that, so far as I have seen, no notice has ever been taken of the fact that the carbon in the gases followed the same law. While engaged in investigating the action of furnace gases on the ore a peculiarity was observed previously unknown to me, viz. that large quantities of carbon were deposited by the dissociation of the reducing gas, the action being $2CO = CO_2 + C$. Experimentally I ascertained that spongy iron, as well as oxide of iron, was capable of producing the change, and that 30 per cent. of carbon dioxide, mixed with the carbonic oxide, arrested the reaction, the temperature at the time being 420°. Dr. C. A. Wright, who subsequently became chief chemist of our laboratory, was asked to continue the examination. The conclusion arrived at was the impossibility of effecting the complete reduction of E_2O_3, or of any oxide by CO. On the contrary, when metallic iron known to contain no oxygen was exposed to a current of this gas, carbon was deposited and oxygen absorbed. It would seem, therefore, that this absorption of oxygen by the iron and precipitation of carbon suffice to explain the disappearance of these two elements from the gases, and that they remain in this condition until the fusion of the iron, in contact with intensely heated carbon, liberates the oxygen as well as that portion of the carbon which is not absorbed by the metal in order to produce pig-iron.

So far, then, as the analyses given in Table III. enable us to judge, instead of the upper two-thirds of a furnace being required for the purposes of reduction, no material change is effected after passing through eighteen feet in a modern furnace of 80 feet in height. After this the composition of the gases, and, therefore, of the minerals, remains pretty steady until the vicinity of the *tuyères* is reached, with the consequences already referred to.

Of the excess of oxygen at the zone of combustion it is highly probable that a portion is due to the reduction of P_2O_5, S_1O_2, SO_3, and CaO. In the case of Cleveland iron I have estimated this at 54 parts per 1000 of pig-iron produced, but the average total oxygen beyond that furnished by the blast in the first two instances given was 130 parts. At this rate there must have been 76 parts of oxygen liberated from the oxide of iron, which is equal to 19 per cent. of that originally combined with the iron in the ore.

It may be appropriate here to refer to what may be taken as a typical expression of the working of a blast furnace in respect to the presence of carbon dioxide. An analysis of the gases is therefore inserted, drawn from an 80-feet furnace at various levels, with the simple remark that it is improbable that carbon dioxide can exist for any length of time when exposed to incandescent coke at the temperature which prevails at the depths mentioned in the last two columns.

TABLE IV.—*Showing what may be regarded as a typical instance of the absence of Carbon Dioxide in the gases taken from a furnace of* 80 *feet. Measurements taken from the highest level of the minerals*, i.e. 8 *feet below charging plates.*

Depth below charge	Escape pipe.	3½ feet.	9¾ feet.	16 feet.	22½ feet.	28¾ feet.	35 feet.	41¾ feet.	66 feet.
Carbonic acid ...	16·07	11·71	10·03	8·17	6·12	—	—	0·72	3·01
Carbonic oxide	27·34	29·71	31·39	31·40	32·79	35·27	36·00	36·02	39·47
Hydrogen ...	0·11	0·10	0·07	0·14	0·28	0·10	0·11	0·08	0·14
Nitrogen ...	56·48	58·48	58·51	60·29	60·81	64·63	63·89	63·18	57·38
Total ...	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Something like forty years ago the escaping gases from the blast furnaces, rich as they were in carbonic oxide, were permitted to burn wastefully on the surface of the minerals charged at the throat. This meant a loss of about 54 per cent. of the heating power of the coke. For reasons already given it was of course impossible to utilize much of this heat in the actual smelting of the ore because of the necessity of preserving a large excess of carbonic oxide in the gases. This, however, constituted no reason why, apart from the furnace work itself, this vast quantity of gaseous fuel should not have been utilized, as it no doubt would earlier have been, had the ironmakers known, as they now do, its full value. To-day all the blast and other engines are driven and the air is heated at our blast furnaces by fuel formerly wasted, and this without any labour for stoking being required. In Great Britain alone the annual saving is fully equal to four million tons of coal.

In connection with the other volatile products which accompany the iron smelters' work I will only mention ammonia. Some qualities of coal admit of being used in the raw state. In this case, as in distilling coal for illuminating purposes, ammonia is generated and may be collected. Instead, however, of the ammoniacal vapour being all contained in the hydrocarbons as in gas-making, it is diluted in addition with all the fixed carbon as oxides and all the nitrogen of the atmospheric air used in its combustion. Nevertheless, Messrs. Bairds, of the Gartsherrie Works, and others, are manufacturing large quantities of ammonia sulphate from the ammonia so obtained. A similar object is achieved by attaching the necessary condensers to the apparatus for coking coal. The process of distillation is then carried on in hermetically closed ovens heated by the combustion of the gases evolved. These, before reaching the fireplace where they are burnt, are deprived of their ammoniacal vapours by passing through condensers provided for the purpose. Previous, however, to this being done, the waste heat from the coking process had been applied for generating steam, so that at certain collieries in the county of Durham all the mechanical power is obtained without any coal being specially burnt for this purpose.

Before speaking of the next and last great improvements in connection with my subject, I should like to say a few words, and a few words only, respecting steel, a well-known and most valuable compound of iron and carbon. Let me first observe that it seems improbable that this substance was not earlier known to the ancients, as was at one time supposed. The facility with which the metal combines with carbon renders it very unlikely that acieration would not occasionally take place when iron itself was the object of the manufacturer. Certain it is that Agricola, who wrote in 1556, describes in Latin a mode, apparently as well known as that of making iron itself, of making *Acie.* The engraving in his "De re metallica" shows bars of malleable iron placed upright in a charcoal fire resembling that of a Catalan hearth. These, after an exposure of several hours to the incandescent charcoal and hot carbonic oxide, were found changed to steel and employed as such.

After the invention of the blast furnace, pig-iron was placed in a similar hearth, and while in a melted state a blast of air was directed upon the molten metal, until just as much carbon remained with the iron as constituted steel. This mode of procedure continued to be practised long within my own recollection, and may, for what I know, still be followed in some districts. The subject of steel-making occupied the attention of Hassenfratz, of Réaumur, and others, but practically the only process followed until 1865 was the well-known one of cementation.

Since the days of Fourcroy it was ascertained that in addition to the iron, carbon was an essential ingredient in cast metal, bu invariably accompanied by more or less silicon, and wheneve the minerals contained sulphur or phosphorus these metalloid were also present. The nature of the actions employed fo ridding the product of the blast furnace of these substances so a to render it malleable had also been carefully examined and explained by the light of scientific investigation. The manufacturer had, it is true, learnt by experience and observation how to produce an article of excellence without much knowledge of the science of his art. Among other things he ascertained that to obtain a ton of wrought iron he required the heat of an equal weight of coal in the puddling furnace; but he did not know, (nor did even men of science, I think, ever dream, that the oxidation of the metalloids in the pig-iron, and that of a small portion of the metal itself, would afford heat enough to enable the workmen to dispense with the use of all coal in the process of conversion. When, therefore, the iron trade was informed, in a paper read before the British Association in 1856, entitled "A Mode of making Iron without the use of Fuel," its author, Henry Bessemer, was set down by the iron trade as a deluded enthusiast. At that period I doubt whether ten pounds of wrought iron had ever been seen in a state of fusion at one time. Bessemer, in his description, however, spoke of melting tons of it with no more heat than that afforded by the rapid oxidation of about 5 or 6 per cent. of the weight of the pig-iron used. Not only, therefore, was the subject one of economic but also of high scientific interest. Nevertheless, a mere statement of the title of the paper was all the notice bestowed by our predecessors in their Transactions on a discovery which has revolutionized the art of making iron. It is quite true that for some time it appeared as if the scientific aspect of the question were to constitute its only recommendation, for the malleable iron made in a Bessemer converter proved unmanageable when hot, and destitute of strength when cold. Finally it was ascertained that phosphorus was the source of the evil, and, further, that while carbon and silicon could be almost entirely removed from the molten metal, this third metalloid remained unaffected by the treatment. The extent to which the hurtful influence of phosphorus makes itself felt in the wrought iron obtained by the Bessemer process is somewhat remarkable, because while two- to three-tenths per cent. is often present in puddled bars of fair quality, probably no consumer would accept Bessemer steel when it contains half of this amount. The first success was obtained in Sweden, where by using pig-iron containing a mere trace of the objectionable substance a product was obtained which was satisfactory. For many years the beneficial effect produced by manganese on steel had been well known, and it occurred to R. F. Mushet, son of David Mushet, one of, if not the earliest scientific metallurgist in the United Kingdom, to try its influence in the converter on iron made from the hæmatite iron of the west of England which contained from 0·05 to 0·1 per cent. of phosphorus. This addition, apparently by its removing occluded or combined oxygen in the molten iron, afforded the necessary relief, and the operation being one of extreme simplicity enables steel or wrought iron to be produced at a greatly reduced cost. To such an extent has this been carried, that ore is brought by sea over a distance of 1000 miles to Middlesbrough, and from it steel rails are made more cheaply than a greatly inferior article of iron can be produced from the abundant and economically wrought bed of ironstone found within a couple of miles of that town. As an example of the facility of conversion may be adduced the fact that the molten metal is brought direct from the blast furnace, turned into steel or ingot iron as the case may be, and the heat evolved by the operation is sufficient to enable the product in many cases, without further use of fuel, to be taken direct to the mill and rolled into a finished bar.

We have just seen that 0·1 per cent., or thereabouts, of phosphorus renders steel or ingot iron valueless; in like manner very insignificant variations in the quantities of carbon or silicon materially affect their quality. Now the blow, as it is termed, in a Bessemer converter may be accomplished in from twelve to fifteen minutes. It is clear, therefore, the opportunity of ascertaining the precise quality of the steel is one of very short duration. It is, I think, not disputed that a product can be obtained by this process possessed of very high, if indeed not of the highest excellence; but it is also pretended that the quality is not sufficiently uniform for certain purposes. The ordinary reverberatory furnace is incapable of affording the necessary temperature for melting steel or wrought iron, but by employing the fuel in a gaseous state, and by heating the air and gas before they are brought together, as is done in the valuable furnace suggested by the Messrs. Siemens, the heat is so intensified that wrought iron in it is rapidly fused. Steel is now largely made in such furnaces, either by mixing wrought and cast iron, as proposed by M. Pierre Martin, or by means of cast iron alone, when the carbon is removed by the addition of iron ore and some limestone, in which case, by the agency of the ore, the metalloids are oxidized and removed from the bath of iron. Some hours being required for this, sufficient opportunity is afforded for ascertaining the progress of the operation.

The cause of the iron in the Siemens furnace as well as in the Bessemer converter retaining its associated phosphorus, in time began to attract the attention of chemists. In each case the expulsion of the metalloids is effected by oxidation. The carbon is gasified, and the silicium on being acidified is absorbed, and forms a slag containing usually 40 to 50 per cent. of silicic acid. In the presence of such an excess of this substance, any phosphoric acid, if formed, could not be absorbed by the slag. It was the late M. Grüner, of Paris, who, in 1867, first pointed out this fact, and he it was who first recommended the use of lime in order to render the slag basic instead of acid. Further, in order to avoid the presence of silica, he recommended at the same time that the converter should be lined with lime instead of with fire-clay.

The same subject engaged my own attention, when guided by the fact that, as oxide of iron in the puddling furnace was capable of acidifying and removing a large quantity of the phosphorus as iron phosphate, it might be possible by keeping the temperature of the metal below that required for the process of puddling to make this removal more complete. The result of these experiments was communicated to the Iron and Steel Institute in March 1877, when it was shown that pig-iron containing 1·75 per cent. of P could in a few minutes have this reduced to 0·2 per cent.

The rapid destruction of the ordinary Bessemer converter led Mr. G. I. Snelus to consider the practicability of using a lime lining, and on experimenting with this on a working scale he confirmed the opinions previously enunciated by Grüner, by observing that the presence of lime had removed a considerable quantity of the phosphorus. These discoveries constitute the foundation of the very important basic process of Messrs. Thomas and Gilchrist, which consists in adding lime to the molten steel in a converter constructed on the principle described by Mr. Snelus. Considerable difficulty had, however, been experienced by this metallurgist in the attachment of the lime lining to the walls of the converter. This important question was solved by Mr. Edw. Riley by exposing dolomite to a very high temperature in order to prevent further shrinking, and then grinding and mixing the powder with coal tar. This formed a species of cement which is applied to the sides and bottom of the converter in the form of bricks or as cement.

The acidification and subsequent transference to the slag of the phosphorus by the basic treatment has led to its application to agriculture. For this purpose the slag is ground to a fine powder, and sprinkled over the land without any further preparation. By this operation an indispensable element of animal life is derived from the remains of living creatures which, ages ago, found a grave in the ferruginous mud destined to become the great Cleveland bed of ironstone.

Before closing this portion of my official duty, I cannot refrain from tendering to chemists an assurance of the great advantage the manufacturers of iron feel they have derived from the lessons taught them by chemical science. I am the more anxious to do this because we, among others, have been reminded that we are losing the supremacy among industrial nations we once enjoyed for want of that knowledge of chemistry which is more assiduously cultivated abroad than it is in our own country. I am not prepared to deny that the opportunities for acquiring a scientific education are less generally spread here than is the case in France, Germany, or Belgium, but for this the nation, and not the iron trade in particular, is responsible. It must also be admitted that as manufacturers we no longer stand so far above other lands as we formerly did. In this result any differences of education are in no way concerned, for if I were to classify the nationalities of the various inventions enumerated in the course of my remarks, the fears of those who are alarmed at the appearance of a Belgian girder or a German steam-engine on our shores would, I think, be allayed. Perhaps I might be allowed to offer a very few words on the technical side of this important question of education. Much I shall not be able to say, because I have not yet been able to learn the precise position the subject occupies in the minds of its most earnest advocates. If it means, as is sometimes alleged, a system by which, along with scientific instruction, manual dexterity in the use of tools, or a practical knowledge of various manufacturing processes has to be acquired, I confess I am not sanguine as to the results. Certain I am that if foreign workmen are more skilful in their trades, which, as a rule, I doubt, and which in the iron trade I deny, this superiority is not due to scientific training in the manner proposed, for in this they possess, so far as I have seen, no advantage over our own workmen. My objection to the whole system is the impossibility of anything approaching a general application being practicable. I have not a word to say against the rudiments of science being taught wherever this is possible. The knowledge so obtained may often give the future workman a more intelligent interest in his employment than he at present possesses; but I think they who expect much good to attend such a thin veneer of chemistry or physics do not take sufficient account of the extent of the knowledge already possessed by more highly educated men who are now directing the great workshops of the world. It is by extending and enlarging this that substantial aid has to be afforded to industry and science, and not by teaching a mere smattering in our primary or any other schools. In the case of young people who from necessity must leave the school-room at an early age, my own leaning is towards the present system, with the addition of drawing and some natural science. By it certain important lessons are taught, which, if not followed under the discipline of the schoolmaster, run some risk of being entirely neglected. After this, probably, the playground will be found more useful and much more popular with school-boys than trying to learn a trade by means of tools which, before he has to use them in earnest, may be thrown into the scrap heap.

As a national question the attention of the Government, Imperial or municipal, ought to be directed to the importance of establishing in all great manufacturing centres institutions resembling that of the Physical College of this city. These should consist of appropriate and even handsome buildings, properly furnished with all the instruments and appliances required for teaching the sciences in their practical bearings on industrial pursuits. In Newcastle, as well as in other places, this has been done on a fairly ample scale, and the advantages the College of Science in this city are capable of affording are offered on such terms that no one can plead expense being a barrier to mental improvement.

Bearing in mind the importance of the subject, and remembering, as my colleagues and myself do, the difficulties we have had to encounter and those we have still before us, I am strongly of opinion that the erection and maintenance of colleges of science should not be left to the accidental liberality of the few, but should be taken in hand by the nation at large.

NOTES.

AMONGST the recent scientific missions undertaken by order of the French Government are: one by Prof. Viault, of Bordeaux, in the table-lands of Peru, Ecuador, and Bolivia, to continue the investigations of the late M. Paul Bert into rarefied air; one by M. de Coubertin, Secretary of the Committee for the Encouragement of Physical Exercises in Education in the United States and Canada, to visit the Universities and Colleges, to study the working of the various athletic associations frequented by the young people of these countries; one by M. Jacques de Morgan, mining engineer, to explore those parts of Asia Minor lying between the south of the Caspian Sea, Armenia, the Gulf of Alexandria, and Anti-Taurus (this mission will occupy two years and three months); and one by M. Candelier, to Columbia, to make ethnographical researches and collections for the State.

MESSRS. LONGMANS have made arrangements with Dr. Nansen for the publication, both in London and New York, of an account of his recent expedition across Greenland. The book will be fully illustrated, and will probably be published in the spring of next year.

THE twenty-sixth annual meeting of the British Pharmaceutical Conference was opened at the Durham University College of Science, Newcastle, on the 10th inst., when the President, Mr. C. Umney, delivered the annual address.

THE Department of Botany, British Museum, has acquired the collection of microscopic slides made by the late Prof. de Bary.

A CORRESPONDENT of the *Daily Chronicle* states that particulars have reached Constantinople, of a volcanic eruption which occurred some days ago in the province of Erzeroum, destroying the village of Kantzorik, and the majority of its inhabitants. Kantzorik was a little village of 215 inhabitants, situated in the Caza of Tortoum, about 60 kilometres north of the city of Erzeroum. The village nestled in a narrow fertile valley about 1600 metres above the level of the sea, on the slope of the eastern mountains. Before the eruption the inhabitants were startled by subterranean noises, and they noticed at the same time that the springs on a mountain which stands at the eastern end of the valley were dried up. Alarmed at these phenomena they appealed to the nearest local authorities, and were advised at once to evacuate the village. The warning for the majority was too late. Towards midday, whilst the terrified peasants were preparing for flight, the eruption came. The torrent rushed down, bearing on its molten surface boulders and masses of earth torn from the surface or belched from the heart of the mountain. The whole village, with 136 persons, was engulfed in the stream.

IT is reported from Japan that Viscount Ennomoto, the new Minister of Education, is devoting special attention upon the introduction of technical education into the primary schools of the Empire, and that he has turned to Italy as a model. His scheme is to include technical education in the curriculum of the preparatory schools, and to give children technical training from the outset.

MR. BOTHAMLEY, Assistant Lecturer and Demonstrator in the Chemical Department of the Yorkshire College, has been unanimously elected President of the Photographic Convention of the United Kingdom for the meeting in 1890, which is to be held at Chester.

THE "Hand-book of Newcastle and District," compiled in view of the meeting of the British Association there this year, consists of three parts, a third being on the geology of the district. The volumes are very neatly got up and well printed. The general hand-book is by the Rev. Dr. Collingwood Bruce, the greatest living authority on the antiquities and history of the district, who has succeeded in making a highly readable and instructive volume. In a short introduction he shows the immense progress made by Newcastle since the last two visits of the Association, and especially since the introduction of railways. Dr. Bruce gives many reminiscences of the old life of Newcastle, and interesting details as to its historical buildings, as well as its modern institutions. In an appendix, brief descriptions are given of the places of interest in the vicinity of Newcastle arranged in alphabetical order. The second volume is devoted to the industries of Newcastle and the north-east coast, and is edited by Mr. Wigham Richardson. Each section is written by a specialist, and the whole is well illustrated by a fine series of maps and diagrams. We have chapters on agriculture, by Mr. Thomas Bell; railways from the Tweed to the Tees, by Mr. W. G. Laws; the harbours of the north-east coast, by Mr. P. J. Messent; mining and quarrying, by Mr. J. Boland Anderson; engineering, by Mr. W. Boyd; shipbuilding, by Mr. J. A. Rowe; electricity, by the Hon. C. A. Parsons; manufacture of iron and steel, by Mr. C. Lowthian Bell; lead, by Mr. N. C. Cookson; copper, by Mr. George Gatherall; antimony, by Mr. N. C. Cookson; zinc, by Mr. John Pattison; aluminium, by Mr. Curt Netto; chemical manufactures, by Mr. T. W. Stuart; gas-works, by Mr. W. Hardie; printing, by Mr. Sidney Reid; manufacture of paper, by Mr. W. H. Richardson; flour milling, by Mr. Edmund Procter; leather manufacture, by Mr. D. Richardson; tanning, by Mr. G. Angus; coachbuilding, by Mr. J. Philipson; earthenware, by Mr. H. Heath and Mr. C. T. Maling; photography, by Mr. Edwin Dodds; carpeting, by Mr. A. Henderson; cement, by Mr. J. Watson; the development of the Portland cement industry, by Mr. J. L. Spoor; ropemaking, by Mr. R. Dixon; the brewing trade, by Mr. T. W. Lovibond; tobacco, by Mr. J. Harvey; with a concluding section by the editor. The geology section is by Prof. Lebour, and is much above the average of similar hand-books.

DR. RUDOLPH KOENIG, the well-known constructor of standard acoustical apparatus in Paris, has just made a discovery of extreme importance in the theory of music, the details of which he will expound at the forthcoming meeting of the Naturforscher at Heidelberg. This is an extension of Helmholtz's theory of *timbre* to certain cases not represented in the elementary mathematical theory, and corresponding to the actual case of the *timbres* of certain musical instruments. The paper is certain to give rise to discussion, and will be of interest to musicians, who have never, as is notorious, taken kindly to Helmholtz's theory in its original form.

FROM an official summary of the proceedings at the German Anthropological Congress, which met at Vienna last month, it appears that after Prof. Ranke had read the year's report, in which the establishment of chairs of anthropology at German Universities was specially mentioned, Prof. Virchow read a paper on the progress of anthropology in the last twenty years. He thought in the next twenty years anthropologists would be able to explain the connection of the various races and peoples of Europe. Prof. Schaafhausen dealt with the present condition of the study of crania for anthropological purposes, and Prof. Ranke with the position of the ears in different races. Dr. Waldeyer described certain investigations of his into the placenta in the human species and in apes, while Prof. Zuckerkandl spoke of the physical qualities of the inhabitants of Styria and Carinthia. Amongst other papers were the following:—Dr. Hoernes, the present position of prehistoric studies in Austria; Herr Troeltsch, the protection of prehistoric antiquities; Dr. Woldrich, the Stone Age in Central Europe; Prof. Virchow, "Crania Americana"; and quite a number of writers described particular prehistoric discoveries, "finds" of bronzes, stone implements, &c.

On Thursday afternoon last a statue was erected at the Veterinary School at Alfort to the memory of Henri Bouley, who after being a professor there, held a chair at the Museum of Natural History, and who before the close of his career was President of the Academy of Sciences. He was the author of books on veterinary medicine and rural economy, which gave a great impulse to French agriculture. He made successful efforts to raise the education and social position of veterinary surgeons. The statue bears the words, "To Henri Bouley, 1814–1885; his pupils and his friends."

Recently we referred to an entomological tour about to be undertaken in Ceylon on behalf of certain German Museums, by Herr Frühstorfer, a Berlin naturalist. The Ceylon papers now contain an account of the tour in the island, and its results, from which it appears that he left Colombo at the beginning of April, and went *viâ* Ratnapura and Pelmadulla to Balangoda, in the neighbourhood of which place he stayed for some time, and then he took a trip over the hills to the low country round about Bintenne. In this neighbourhood he stayed altogether ten days, after which he made his way to Belihuloya, which he describes as most interesting country for naturalists, the hills round offering fine scope for the insect-trappers. Here he collected some very good specimens, principally dragon-flies of scientific interest. Beetles were also plentiful, and he was successful in obtaining some excellent specimens of the rare family of the *Cetonidæ*, and also captured one or two of the leaf-butterflies, which are so seldom seen, and so difficult to catch when seen, owing to the practice they have when pursued of flying to a bush or a tree, where their peculiar colour and shape, assimilating to the colour and shape of the leaves, render detection almost impossible. On May 6, Herr Frühstorfer went on, *viâ* Haldumulla and Koslande, to Wellaway, where he collected some beautiful butterflies, notably several specimens of the family known as *Papilios* (*montanus*). In the jungle near the Kottiyagalle estate, he captured some splendid butterflies, and an almost incredible number of grasshoppers. Here he collected, amongst other interesting specimens, a number of the insects which, from their red bodies and golden crests, are called "soldier" grasshoppers. Returning to Colombo for a time, he made an excursion to Panadura and the Bolgodde lakes, where he found centipedes of all kinds, including many rarities. On July 8 he journeyed to Kandy and Matale, and on to Dambool, where he stayed a week, and where he gathered his best specimens of *Orthopteras* or locusts, amongst them being some leaf-locusts of beautiful shape, and golden beetles, which are greatly in request by collectors and museums. While in the neighbourhood of Dambool he visited Anuradhapura, and thence he went on, over Habboorenna, to Kanthalai and Trincomalee, where he added to his store of butterflies.

Herr Frühstorfer, however, did not work alone. He employed altogether fourteen other collectors, who have been collecting for him in all parts of the island, and the result is that he has now a gigantic collection, the number of which he says it would be difficult to estimate; but he thinks he is well within the mark in saying that it includes 25,000 beetles, about 7000 butterflies, about 3000 *Orthopteras*, a like number of dragon-flies, and a thousand spiders and centipedes. He has a large number of butterflies and *Orthopteras* that are not to be found in the Colombo Museum; while, numerically speaking, he says he has more than three times the number of dragon-flies to be seen there. Amongst his most valuable specimens are the leaf-butterflies and locusts, and the long-horned beetles and *Mantidæ*. Besides all these, he has a good collection of snakes, amongst which are cobras, sea-snakes, and specimens of the *Uropeltidæ* and false snakes. Besides reptiles, Herr Frühstorfer has a valuable collection of shells. He describes Ceylon as being a very rich field for naturalists.

At the July meeting of the Anthropological Society of Bombay, Mr. Kitts, of the Indian Civil Service, read a paper on the early history of Northern India, in which the theory recently put forward by Mr. Hewitt, on the early history of India, was stated and discussed. The theory of Mr. Hewitt is briefly this:—That the first immigrants who settled in India and have left traces surviving were the so-called Kolarian races, who came from the north-east, and that their descendants, to the number of ten millions or thereabouts, are still occupants of Northern India. The Kolarians were succeeded and conquered by the Dravidians, who came from the north-west, and developed in India a very high state of civilization, both social and political. Large estates belonged to single owners, such as the *talukdari* tenures in Northern India, and the *zemindari* and *patidari* tenures in Southern India. "In short," says Mr. Hewitt, "it was the Dravidians who founded and consolidated the present land revenue system of India." The Dravidians also organized the *punchayet* and *chowkidar* system of village government, which has survived to the present day. All the manual arts and industries practised in the India of to-day were known to and practised by the Dravidians. The Aryans, migrating into a land occupied as India then was by the Dravidians, with a strongly-organized system of government, found great difficulty in obtaining a foothold, and even when they had secured a tract of country in the north-west for themselves, did not obtain supremacy over the rest of India by force of arms. The agents of their subsequent advance were three—religion, commerce, and military ability. Friendly alliances were concluded between the new-comers and the snake races of the Dravidians. The Aryans admitted the noble races of the Dravidians to be of royal blood, and accepted Siva or Lingam worship as not dishonouring to their religion. The Dravidians, thus recognized as of noble blood, were the ancestors of the modern Rajpoots and the Kshatriya caste. Intellectually the Aryans were far superior to the Dravidians, and the Aryan tongue was accordingly adopted as the *lingua franca* for commercial purposes. So, too, the Aryan became a necessary element in every court and in every commercial enterprise, and from this time forward (about six centuries B.C.) their supremacy was assured.

A recent issue of the Japanese *Official Gazette* contains an elaborate table showing the number of earthquake shocks felt in Tokio, and registered at the Central Observatory, from 1875 to 1889. The *Official Gazette* says that a large part of the area on which the city of Tokio stands, being of the character of alluvial deposit, is exceptionally sensitive to shocks of earthquake. These statistics, covering a period of fifteen years, unmistakably indicate the three closing and the three opening months of the year as the period of maximum seismic activity for Tokio. March is *the* month, *par excellence*, and next to it comes December. The order in respect to frequency of shocks is March, December, February, May, January, November, October, April, June, July, September, August.

In a special article of some length on the new Welsh Intermediate Education Act, the *Times* says that, while it recognizes, without supplanting, the higher elementary schools which were so warmly fostered by the Education Department half a dozen years ago, it takes power, not only to deal with intermediate or secondary education, properly so called, but also to become for Wales and Monmouth a Technical Education Act in everything but name. As a Secondary Education Act it will promote instruction in "Latin, Greek, the Welsh and English languages and literature, modern languages, mathematics, natural and applied science, . . . and generally in the higher branches of knowledge." As an Act for furthering technical education, it will promote the teaching of (1) any of the branches of science and art with respect to which grants are, for the time being, made by the Department of Science and Art; (2) the use of tools, and modelling in clay, wood, or other material; (3) commercial arithmetic, commercial geography, book-keeping, and shorthand; (4) any other subject applicable to the purposes of agriculture, industries, trade, or commercial life and practice, which may be specified in a scheme . . . as a form of instruction suited to the needs of the (particular) district. The only restriction to the fullest development of technical science to be aimed at under this Act is set forth in the proviso to the effect that any proposed course of technical instruction "shall not include teaching the practice of any trade, or industry, or employment."

A RECENT issue of the French *Journal Officiel* contains the Report which M. Bouchon-Brandely, Inspector-General of Marine Fisheries in France, has made to the Minister of Marine, on the subject of the cultivation and condition of the natural oyster-banks of Brittany. He visited St. Malo, where he reports the Roma, a river in which oysters have grown for the last fifty years, as being a spot eminently favourable for experiments, on a large scale, in the improved cultivation of this shell-fish. The oysters have been wastefully neglected in the Roma, and at the present time the industry appears to be almost ruined, but to be capable, with a little care, of being restored to a condition of very great importance. Proceeding westward, he found the Bay of St. Brieuc, once a rich oyster-field, entirely destroyed by the reckless use of the dredge. A little further, at Tréguier, he found the oyster-beds still existing which produce the famous Breton oyster, a fish rather larger than the Ostend variety, and not a whit inferior to it in flavour. The fishermen have fished to excess, in spite of all official warnings; they have left the beds no rest or time for growth. The Report suggests a return to the regulations of 1750, by which oyster-fishing in the creek of Tréguier was permitted only once in six years; or, if this be considered too long a close season for practical purposes, to prohibit the fishing for two years at least, during that period to cleanse and tend the beds, to check the wastefulness of the people of the locality, who are in the habit of helping themselves freely to oysters, and to arrange that an ordinary tide, and not the lowest tide in the year, should be chosen for the periodical general fishery. The Report speaks with considerable bitterness of the total destruction of the once flourishing oyster-beds of the Roads of Brest, ruined by every kind of wasteful and improvident fishing. M. Bouchon-Brandely is of opinion that these beds deserve to be replanted, and that, if proper care be taken to protect them, there is no reason why they should not flourish. But it will be necessary, by some penal regulation, to check poaching; and he believes that the expense of maintaining keepers on the oyster-beds would be amply repaid by the profits which would result from the prevention of poaching. Along the coast of the Morbihan the oyster-beds were found to be in a condition much less exhausted than in Finistère, and to be recovering. In the neighbourhood of Vannes a little steamer goes to and fro, watching the oyster-beds, and seeing that they are not disturbed by poachers—a proceeding which has been found to be of excellent service in preserving the fish. At every point, M. Bouchon-Brandely found that the rapacity of the dredgers and the constant disturbance of the young shells had been the principal causes of the rapid decline in the value of the Breton oyster-beds—a decline which has induced the Ministry of Marine to intrust him with these investigations.

THE following observations on the subject of agricultural laboratories in Belgium are taken from a report recently issued by the Agricultural Department of the Privy Council. Every person living in Belgium who purchases not less than a ton of feeding stuffs can have samples of these analyzed, free of cost, at the agricultural laboratory which exercises jurisdiction in the province in which the purchaser resides. In the last number of the *Bulletin de l'Agriculture*, published by the Minister of Agriculture in Belgium, there is a valuable report from the Commissioners appointed to superintend the establishment of agricultural laboratories and to inspect them periodically. From this it appears that there are now seven agricultural laboratories in Belgium where gratuitous analyses of manures and feeding stuffs are made. By a Royal decree, dated August 1887, the agricultural station at Gembloux was reorganized and a distinct agricultural laboratory was attached to it. Besides this there are agricultural laboratories at Gand, Liége, Hasselt, Anvers, Mons, and Louvain. Not only are analyses supplied by these institutions, but information is furnished to agriculturists upon the rational employment of manures, and the best modes of using various feeding stuffs as well as upon other agricultural points. At the station of Gembloux alone there were 227 consultations with agriculturists upon divers questions of agronomy.

A MEMORANDUM by Mr. Charles Whitehead, Agricultural Adviser to the Privy Council, on the subject of the introduction of insects injurious to corn and corn crops in wheat imported from India, has recently been issued. Mr. Whitehead says that the foreign matter mixed with wheat imported from India into this country serves as a medium for the wholesale transportation of insects injurious to crops. From the cleaning of Indian wheat several categories are formed at the flour-mills. One consists of short pieces of straw of from one inch to two inches and a half long, with pieces of wheat ears. This is sold for litter, and is distributed among various farms in the neighbourhood of the mills. In this straw the most dangerous corn insects might be introduced—insects of the type of the Hessian fly, of the *Isosoma Hordei*, the joint worm whose appearance in Great Britain is feared by agricultural entomologists. Another comprises light and misshapen grains of corn with weed seeds, known in this country as "screenings," and which ought to have been taken out of the bulk by the Indian producers. This is purchased for pigs' and chickens' food, being therefore scattered over the face of the land. In this, corn weevils especially and other insects may easily be conveyed. It is well known that weevils are most destructive to wheat and other grains in India. It is also equally well known that they are brought over to British ports and granaries in abundant quantities with Indian wheat. One species of weevil, the *Calandra oryzæ*, the rice weevil, does enormous harm to wheat in Indian granaries, and to wheat while it is being transported in vessels to this country. The admixture of dirt, seeds, and rubbish causes the wheat to heat, which of course is detrimental to its quality, and at the same time causes weevils to propagate unusually and to materially damage it. Sometimes the cargoes of wheat that have been heated are nearly alive with weevils, causing great waste and heavy loss to importers. This loss continues when the bulk is taken to granaries or warehouses where the heat is still evolved, and the weevils revel in it. The amount of loss occasioned by this weevil is estimated at an average of 2½ per cent. Taking the value of wheat exported at £6,000,000, the amount of loss due to this insect in exported wheat alone equals £150,000. Another weevil, the *Calandra granaria*, closely allied to

Calandra oryzæ, is also brought over with Indian wheat. This weevil is known in British and other European granaries, but it is presumed that the heat and surrounding circumstances of cargoes of Indian wheat favour its development and stimulate its powers of destruction. As it breeds freely in this country, the danger of its distribution is great. Besides the actual money loss occasioned by these weevils, it is stated that the flour made from wheat much infested by them is injurious to health.

THE French Consul-General to Bolivia, in a recent Report to his Government, gives some interesting remarks on the population of that remote State. The population, he says, consists of about 1,300,000 persons, and is not homogeneous; it consists of the white race, descendants of Europeans, the Indian, the original inhabitants of the country, and the Mestizos, called Cholos, a mixture of Europeans and Indians. The Indians form more than half the population, and the white race about one-quarter. The manners and customs of the Bolivians vary according to the social group; the white race have much the same customs as Europeans. Special mention is made of a national spice probably little known in Europe. This is pimento (*agi*) which burns the palate, and is largely used in all Bolivian food, and forms an important article of commerce. The continual use of such a hot condiment hardens the mouth, and explains the ease with which nearly all Bolivians can take the strongest spirits. The Indian has very different customs. He sustains himself during work or when hunting by chewing the leaves of the coca, and always carries a quantity with him wherever he goes. As he is addicted to drink, he gets drunk whenever he can. His favourite drink is pure alcohol. On high ground the Indian wears a particular dress summer and winter. This consists of loose drawers, made of coarse linen, which leave the lower part of the legs and feet bare, over these a linen tunic, and a poncho which is used as a mantle. He is accustomed to a hard life, and sleeps in the open air, covered only by a piece of linen, no matter what the weather may be. The morals of the Indian are more than doubtful. His black and glossy hair never receives attention, his red skin acquires a dark colour from the dust which accumulates on his body and becomes part of his epidermis. On *fête* days, men and women cover themselves with tinsel, skins of wild beasts, feathers of every shade, and dance and drink until exhausted by fatigue and drunkenness they throw themselves on the ground. This race, which is interesting from the novel spectacle it presents to the stranger, has but little apprehension of the benefits of civilization; it carries on, however, the agriculture of the country. The Cholo or half-castes already mentioned belong to the least estimable part of the population. They get drunk frequently and work little; they wear trousers and a vest, over which is thrown a poncho. They are almost always immoral and dishonest; wherever there is a disturbance there they are to be found. They are the handicraftsmen of Bolivia, and are not without some skill.

THE *Meteorologische Zeitschrift* for August contains a discussion of the daily period of the humidity in Christiania, by J. F. Schrœter, based upon an old series of hourly observations made at the Observatory between 1841 and 1847. The vapour-tension exhibits the usual periods of double maxima and minima. The relative humidity shows a strongly-marked maximum in the morning, and minimum in the afternoon; the epoch of the maximum occurs earlier from the winter to the summer solstice, and *vice versâ*. Dr. A. Wachlowski contributes a paper on the rainfall of Galicia. The yearly period is a very simple one; there is a maximum in July, and a minimum in January and February. The country is divided into seven districts, in which the annual rainfall varies from 24½ to 26½ inches.

THE additions to the Zoological Society's Gardens during the past week include a Common Marmoset (*Hapale jacchus*) from Brazil, presented by Mr. James Waddell; three Bengal Foxes (*Canis bengalensis*) from India, presented by Colonel Creek; a Common Badger (*Meles taxus*), British, presented by Mr. G. H. Hulme; a Grey Ichneumon (*Herpestes griseus*) from India, presented by Miss Colvin; a Crested Porcupine (*Hystrix cristata*) from Ceylon, presented by Captain Rose; a Ringed Plover (*Ægialitis hiaticula*), British, presented by Mr. H. M. Upcher; a Red-billed Tree Duck (*Dendrocygna autumnalis*) from India, presented by Mrs. Alfred Oakes; five Hobbies (*Falco subbuteo*) from Spain, deposited; two Upland Geese (*Bernicla magellanica*, var. *dispar*, ♂ ♀) from Patagonia, two Spur-winged Geese (*Plectropterus gambensis*) from West Africa, two Black-backed Geese (*Sarcidiornis melanonota*) from India, purchased.

OUR ASTRONOMICAL COLUMN.

THE TRIPLE STAR Σ 2400.—In the year 1884 a third star was discovered by M. Perrotin, lying nearly midway between the two components which had been discovered by Struve in 1829. Mr. Burnham, writing to the *Observatory* under date July 31, 1889, now points out that the observations made of the three stars show that the change in position of the two companion stars is wholly due to the proper motion of the principal star, that the two fainter stars are substantially fixed with regard to each other, and may possibly prove to be physically connected, though with but slow motion, and that, thirdly, Struve's observation in 1872 was of the new, and not of the old, companion. It appears curious that the inner companion was not discovered earlier, as it is almost as bright as the outer one. The large star is moving away from the fainter, so that measurements will be rendered easier in the future.

THE POTSDAM OBSERVATORY.—The second part of the fourth volume of the Publications of this Observatory has just appeared. It is given up to solar physics, the heliographic latitudes and longitudes of the sun-spots from 1880–84 forming the first section; Herr Wilsing's research (see NATURE, vol. xxxviii. p. 206, June 28, 1888) on the rotation period of the sun as derived from the observation of faculæ, the second; and a description of Dr. Lohse's photoheliograph, and of the method employed at the Observatory for the measurement of the solar photographs, the remainder of the volume.

THE OBSERVATION OF SUDDEN PHENOMENA.—Prof. Langley, in the *Sidereal Messenger* for August, proposes a method for greatly diminishing personality in the observation of sudden phenomena, such as the disappearance of a star when occulted by the moon. The principle of the method, which is susceptible of a wide application, consists in associating a motion, real or apparent, of the object with intervals of time, so that the apparent position of the object at any occurrence being noted, the time of the occurrence will be known. For the apparent position, say, of a star at occultation is an integral part of the phenomenon observed, and does not depend for its correct estimation upon the rapidity with which the mind can pass from one order of impressions, as the sight of a star in the field of a telescope, to another, such as the estimation of the interval that has elapsed from the last beat of a pendulum. Some preliminary experiments with an eyepiece, in which the star under observation was made to appear to revolve once in a second, showed that it was quite possible to observe an occultation with a probable error of only one-fortieth of a second.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 SEPTEMBER 15–21.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 15

Sun rises, 5h. 37m.; souths, 11h. 55m. 1·0s.; daily decrease of southing, 21·2s.; sets, 18h. 13m.: right asc. on meridian, 11h. 33·6m.; decl. 2° 52′ N. Sidereal Time at Sunset, 17h. 53m.

Moon (at Last Quarter September 17, 5h.) rises, 20h. 41m.*; souths, 4h. 18m.; sets, 12h. 7m.: right asc. on meridian, 3h. 55·3m.; decl. 17° 7′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	8 9	13 26	18 43	13 5·1	9 8 S.
Venus.....	2 7	9 36	17 5	9 13·9	16 11 N.
Mars......	2 54	10 13	17 32	9 51·0	14 19 N.
Jupiter....	14 24	18 17	22 10	17 56·3	23 28 S.
Saturn....	3 9	10 23	17 37	10 0·7	13 28 N.
Uranus...	8 12	13 38	19 4	13 16·7	7 29 S.
Neptune..	20 44*	4 34	12 24	4 11·7	19 25 N.

* Indicates that the rising is that of the preceding evening.

Sept.	h.	
20	8	Mars in conjunction with and 0° 1′ north of Saturn. Some interesting particulars, by Mr. Marth, concerning the near approach of these planets are given in the *Monthly Notices* of the R. Astron. Soc., vol. xlix. p. 424. Observations of the appearance which the planets will present, by persons not possessing telescopes, will be especially interesting. The bright star Regulus will be in the immediate vicinity.
20	23	Mercury at greatest elongation from the Sun, 26° east.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′			h. m.	
T Arietis	2 42·1	17 3 N.	Sept.	16,		*m*
Algol	3 1·0	40 32 N.	,,	16,	22 52	*m*
U Coronæ	15 13·7	32 3 N.	,,	16,	21 25	*m*
W Herculis	16 31·3	37 34 N.	,,	20,		*M*
U Ophiuchi	17 10·9	1 20 N.	,,	18,	23 13	*m*
X Sagittarii	17 40·6	27 47 S.	,,	16,	1 0	*M*
U Sagittarii	18 25·6	19 12 S.	,,	18,	0 0	*m*
β Lyræ	18 46·0	33 14 N.	,,	17,	21 0	m_2
			,,	21,	2 0	*M*
S Vulpeculæ	19 43·8	27 1 N.	,,	21,		*m*
η Aquilæ	19 46·8	0 43 N.	,,	20,	0 0	*m*
S Sagittæ	19 51·0	16 20 N.	,,	15,	1 0	*m*
R Sagittæ	20 9·0	16 23 N.	,,	21,		*m*
X Cygni	20 39·1	35 11 N.	,,	18,	22 0	*m*
T Aquarii	20 44·1	5 34 S.	,,	15,		*M*
δ Cephei	22 25·1	57 51 N.	,,	20,	1 0	*m*

M signifies maximum ; *m* minimum ; m_2 secondary minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near ε Tauri	65	22 N.	Swift ; streaks.
,, η Aurigæ	75	41 N.	,, ,,
,, ν Orionis	90	18 N.	,, ,,
	98	43 N.	,, ,,

GEOGRAPHICAL NOTES.

The Indian Survey Department has just issued the second edition of an elaborate coloured map of India in six sheets, fully corrected up to 1888. The scale is 32 miles to the inch, and the details are most minute. British territory is clearly marked as well as dependent and subordinate native States, and independent countries and foreign possessions. Main and minor roads too are clearly noted, and railways open and in progress are indicated, while the position of lighthouses, passes, forts, and canals, is shown in a most precise manner ; another feature is that the altitudes above sea-level of the chief stations throughout India are given. The map was first issued under the direction of Lieut.-General J. T. Walker, C.B., R.E., and is now reissued under instructions from Colonel H. R. Thuillier, R.E.

It is reported from Honolulu that H.M.S. *Espiègle* arrived there on August 28, after annexing Humphrey and Rierson Islands, in the Manihiki Group, a cluster of small islands in the Eastern Pacific to the north of Cook Islands.

The following letter is published from Captain Grombchevsky, who started last spring for Kafiristan :—"I left Marghilan on July 13, and was compelled to halt owing to the overflow of the River Isfaran and the destruction of the bridges. After vain efforts to cross the snow-covered ridge of Transalai, opposite to Altyn Mazar, I returned to Alai, and reached Kala-i-Khumb, through Karategin as far as Moumina, Lake Yashil, the pass of Gardami, Kafar Vakhia, and Passand. I purposed proceeding up the River Khuf, as far as Lake Shiva, but the borders of the lake were occupied by Afghan troops. I shall therefore go up the Panjah towards Roshan and Shugnan, where Ak Barsba, whose days are numbered, still holds his own. He lately made a bold *sortie* against the Afghans, and took the towns of Ishkashin and Zebac, but, being surrounded by superior and better-disciplined forces of Afghans, he was obliged to surrender both places and retreat on Shugnan. He sent his Afghan prisoners to Darvaz, whence they were sent home by the Bokharan authorities through Kouliab. In three days I shall be in the centre of military operations, and as the issue is certain to be favourable to the Afghans, I am sending a letter to Faizabad, to the Ameer's lieutenant, asking permission to pass through Kafiristan. The letter is carried by a native of Shugnan, who was sold as a slave for his devotion to the Afghans, and is owing his liberty to me. All well, in high spirits and full of energy. I have with me seven Cossacks, two Tekkes, two Kirghiz, one native of Shugnan, and one German."

The following account of M. Bonvalot's tour in Central Asia is taken by the Paris *Figaro* from a letter from the traveller himself. He is accompanied by Prince Henry of Orleans, the eldest son of the Duc de Chartres. They have safely reached the Russo-Chinese frontier, and when the traveller wrote were about to cross into Chinese territory. M. Bonvalot's present object is nothing less than to make his way into Tonquin across China. The following is his proposed itinerary : from Omsk to Semipalatinsk, then to Bakti, next to Chuguchak, and thence onwards in succession through Chicho, Manas, Urumtsi, Karashar, Korla, by the course of the Tarim and Lob Nor to Karkalik, across the Tchamuen Tai by the way of Naichi Gob to Koukon Sai, Tsamdo, Batang, Yunnanfor, and finally Tonquin. M. Bonvalot ends his itinerary with the following reflections :—"A sufficiently hazardous task, perhaps incapable of execution. In a word this is our ideal, but complications and accidents may perhaps compel us to modify it. For the present we hope to reach China as quickly as possible. The approach of winter on the higher plateaus of Tibet frightens me a little, and makes me long to be there."

The Indian mail brings intelligence of the death of Mr. William Watts M'Nair, of the Indian Survey. In 1883, Mr. M'Nair, disguised as a Mahometan doctor, succeeded in reaching the outlying valleys of Kafiristan, travelling by way of the Swat Valley and Chitral. For this adventurous journey, in the course of which he obtained much valuable information regarding the passes of the Hindoo Koosh and about the manners and customs of the Sirjah Push Kafirs, the Royal Geographical Society awarded the Murchison grant. Mr. M'Nair, in whom the Indian Government has lost an able and zealous servant, died at Mussoorie, on August 13, of fever contracted at Quetta.

In answer to telegraphic inquiries, addressed to Tromsö by the Bremen Geographical Society respecting the fate of Dr. Kukenthal, whom they had sent out to explore the North Polar regions, a reply was received a few days ago stating that, although the *Berntina*, on board which Dr. Kukenthal was, had stranded, yet the young explorer and his companion, Dr. Walter, with all their equipment, had been saved. Their voyage had not even been delayed, as they had not returned to Tromsö, but had proceeded in another sealer, the *Cæcilie Magdalena*. In July they intended to press forward on the north coast of Spitzbergen.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

The result of the examination for certificates held in July last under the direction of the Oxford and Cambridge Schools Examination Board has been published. In the examination for higher certificates there were 1161 candidates, of these 64 girls were candidates for letters only. The number of higher certificates awarded was 785, and the number of letters given to girls was 51. The total number of candidates for lower certificates was 709, and the number of certificates awarded was 408. For the newly-established commercial certificates there were 66 candidates, and 25 certificates were awarded.

The following are the statistics so far as scientific subjects are concerned:—

Higher Certificates.

Subject.	No. of Candidates.	Total Passed.	Distinguished.
Mathematics, Elementary	1068	924	0
Mathematics, Additional	483	344	85
Natural Philosophy, Mechanical Division	102	96	47
Natural Philosophy, Physical Division	46	42	21
Botany	23	17	7
Physical Geography and Elementary Geology	46	44	16
Biology	4	3	2

Lower Certificates.

Subject.	No. of Candidates.	Second Class.	First Class.
Arithmetic	709	387	152
Additional Mathematics	638	243	244
Geography	386	153	44
Mechanics and Physics	62	22	14
Physics and Chemistry	60	19	20
Chemistry and Mechanics	44	16	6

Commercial Certificates.

Subject.	No. of Candidates.	Second Class.	First Class.
Arithmetic	66	40	19
Algebra	66	40	18
English	66	28	7
Shorthand	12	2	0
Geography	66	34	4
Inorganic Chemistry	25	6	8
Mechanics	12	8	4
Electricity and Magnetism	19	14	4
Sound, Light, and Heat	15	10	0

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 2.—M. Des Cloizeaux, President, in the chair.—Definitions adopted by the International Congress of Electricians, by M. Mascart.—On the results obtained at Bourganeuf (Creuse), in transmission of force by electricity, by M. Marcel Deprez. The force is conveyed 14 kilometres, from a waterfall, by a bare siliceous bronze wire on posts. Generator and receiver have each 100 nominal horse-power; electromotive force of former 3000 volts. Further details are promised.—On the analytic representation of perturbations of planets, by M. Hugo Gyldén.—Researches on the relations between the carbon of plants and the quantity of fertilizing agents in the soil, by M. Georges Ville. The coloration of leaves varies with the nature of the manure, nitrogen having most effect. The colours of liquids got by treating leaves with alcohol (after extraction of the colouring matter carotine) correspond with those directly observed, but the differences in intensity are less. The orange solutions of carotine (with carbon sulphide) show corresponding variations of intensity with those of chlorophyll.—A prize competition, from Spain, was announced, for a work commemorating the discovery of America (30,000 francs and 15,000 francs).—On Brooks's comet, July 6, 1889, by M. Charlois.—On the aspect and on a companion of Brooks's comet, by M. G. Bigourdan. This companion, observed since the 27th ult., is a small round nebulosity (of magnitude 13·3) on one side of the tail, and 20″ from the nucleus.—Unipolar and bipolar induction on a turning sphere, by M. Ch. V. Zenger. The poles of the electro magnet can be moved towards or from each other, by means of movable coils. The suspended copper sphere, rotated by torsion, with axis near that of magnet, has a spiraloid elliptic movement, which is recorded on smoked paper. M. Zenger seeks to explain the orbital motion of planets and comets, on principles here involved.—Electrodynamic laws and planetary motion, by the same.—New experiments on the poison of the terrestrial salamander, by M. C. Phisalix. The minimum fatal dose of chlorhydrate of salamandrine for a dog is about 1·8 milligrammes per kilogramme of the animal, with subcutaneous injection; 1 milligramme with intravenous injection; and 8 to 10 milligrammes by the stomach. By a series of preventive inoculations a dog can be gradually accustomed to doses otherwise fatal. A dose of 5 to 10 milligrammes subcutaneous, or 1 milligramme intravenous, is fatal to the salamander itself.—On the cardiac effects of centrifugal excitations of the vagus, indefinitely prolonged beyond return of the heart-beats, by M. F. Laulanié. The intracardiac arresting apparatus is not, as has been supposed, exhausted when the heart begins to beat again after stoppage through the vagus.—Catheterism of the ureters, by M. P. Poirier. The bladder is illumined with a cystoscope, containing a small incandescent lamp at the end of the sound, and an optical apparatus, whereby the mouth of the ureter can be easily found, and the small catheter (also included in the cystoscope) inserted.—On the ovogenesis, the structure of the ovary, and the regression of the parenchyma of Gordians, by M. A. Villot.—On the *Polyodontes maxillosus*, by M. Remy Saint-Loup. This relates to the rare capture of a gigantic annelid (2 metres long) in the Gulf of Marseilles. The animal is described.—The protophylline in etiolated plants, by M. C. Timiriazeff. He finds confirmatory evidence of his view that it is protophylline that, oxidizing in light, gives rise to chlorophyll in the living organism. Protophylline is obtained from chlorophylline (*i.e.* chlorophyll minus xanthophyll).

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Ephemeris of Stars in the Vertical of "Polaris," 1889: F. L. Blake (Toronto, Ontario).—Hygiene and Public Health: L. C. Parkes (Lewis).—A Text-book of Organic Chemistry; A. Bernthsen, translated by G. M'Gowan (Blackie).—Cancer and its Complications: C. E. Jennings (Baillière).—A Manual of Pathology, 2nd edition: J. Coats (Longmans).—A Hand-book of Descriptive and Practical Astronomy; I. the Sun, Planets, and Comets, 4th edition: G. F. Chambers (Oxford, Clarendon Press).—Seventh Annual Report of the Fishery Board for Scotland, being for the Year 1888, 3 parts (Edinburgh).—Key to Todhunter's Integral Calculus: H. St. J. Hunter (Macmillan).—An Illustrated Manual of British Birds, Parts 15, 16, 17: H. Saunders (Gurney and Jackson).—University College of North Wales, Calendar for the Year 1889–90 (Manchester, J. E. Cornish).—A Treatise on Elementary Dynamics: S. L. Loney (Cambridge University Press).—The God of the Children: B. Pollard (E. Stock).—Blackie's Modern Cyclopedia, vol. iii. (Blackie).—Proceedings of the Davenport Academy of Natural Sciences, vol. v. Part 1 (Davenport, Iowa).

CONTENTS.

THURSDAY, SEPTEMBER 19, 1889.

THE BRITISH ASSOCIATION.

NEWCASTLE-ON-TYNE, *Tuesday Evening.*

AMID much that has been stale and dull, the present meeting has not been without excitement. The discussions on heredity and Darwinism in D, Mr. Du Chaillu's attempt to make the Vikings responsible for the English-speaking peoples, and Dr. Nansen's appearance in several Sections, have all helped to keep the Sectional work alive, not to speak of the considerable number of papers of special scientific interest. Of the Sectional addresses, those of Prof. Geikie, Mr. Anderson, and Mr. Edgeworth are most spoken of for novelty and interest, the latter, curiously, for the touches of fun, if not humour, that the author succeeded in imparting into what seems at first sight a dry subject.

As to Newcastle itself, everybody is satisfied with the treatment this young city has accorded to the Association, and everybody is pleased to see the footing which science is getting in the place in the splendid new Science and Medical Schools. It is, moreover, gratifying that, in a district where the practical applications of science are everything, distinct acknowledgment should have been made of the value and indispensability of pure scientific research. This was done on two occasions: first, in the admirable speech of the Mayor (of whom all speak well) at the magnificent banquet given by Lord Armstrong; and again before an audience of over 3000 working men in the Drill Hall, when the various trades associations presented an address to Prof. Flower, before Mr. Baker gave his lecture on the Forth Bridge, and thus recognized that only as the result of long series of complicated researches, undertaken solely for themselves, has the accomplishment of such a stupendous undertaking been possible. It goes without saying, that Mr. Baker's lecture was a marked success; it is difficult to describe the enthusiasm evoked from an enormous audience keenly capable of appreciating the points. It was stated that over 8000 applications had been made for tickets, when only 3500 could be allotted.

The social arrangements have been all that could be wished. It would be difficult to convey any idea of the thoughtful arrangements that have been made in many cases to secure the comfort and enjoyment of the visitors, and especially for the hard-worked officials of the Association. The banquets, receptions, *conversaziones*, and other similar features, have been many and excellent; while no fault could be found with the excursions: that to Durham on Saturday gave pleasure to all who joined it, especially to those who were privileged to sit down to the substantial luncheon in the grand old Castle. At the Cathedral service afterwards, it was interesting to see the Sectional Secretaries sitting humbly in the chancel, and a few eminent Presidents of Sections exalted to the stalls of Canons and Prebends.

At the General Committee Meeting yesterday there was unusual excitement. These meetings are generally scantily attended; but, from the crowd which filled the room and hovered around the doors, it was evident that mischief was brewing. After other business was transacted, it was announced, to the evident regret and pain of everyone, that Mr. Atchison could no longer, owing to ill-health, continue to discharge his duties as Secretary, and that a successor would have to be appointed. Mr. Atchison's popularity with the Association was evident from the enthusiasm exhibited in the proposed votes of thanks accorded him. The name of the candidate selected by the Council for the approval of the meeting was then announced, and supported by Prof. Garnett and others. But opposition to the selection was immediately announced. It is unnecessary to report in detail what will probably be found in the daily papers; but it was evident that there was widespread dissatisfaction with the conduct of the Council. No one had any especial objection to this candidate, although he had never had any connection with the Association; but it was felt that the Council had acted unwisely in passing over certain other candidates who were of eminence in science and had had long experience of the workings of the Association. After many proposals had been made, and much excitement manifested, it was at last, almost unanimously, decided to reappoint Mr. Atchison, and authorize the Council to provide whatever assistance should be necessary. Happily, Mr. Atchison said he was willing to agree to this proposal, and so the incident ends at present. But it was expected that the matter might have gone further, and the whole subject of the constitution of the Association discussed, and the advisability of conforming it to existing conditions. Happily, such a discussion has been postponed: it would have been unwise to continue it in connection with so personal a matter.

At the same meeting, the invitation from Cardiff was accepted for 1891, while that from Edinburgh will no doubt be accepted for 1892. The meeting at Leeds, beginning on September 3 next year, will be presided over by Sir Frederick Abel.

It is impossible not to state, what all feel, that the success of the present meeting has been largely due to Prof. Merivale, who has been ably supported by Dr. Bedson, Dr. Dunn, and other members of the Local Committee. That the attendance (2431) is something like a thousand below the last Newcastle meeting, and still less than the Manchester meeting two years ago, is not surprising. Not only are the Paris Exhibition and the many Conferences being held in connection therewith a powerful counter-attraction, but there were in 1863 special local reasons for raising the attendance to so high a figure.

The following is the list of grants to be submitted to the meeting of the General Committee to-morrow:—

A.—*Mathematics and Physics.*

	£
Differential Gravity Meter	10
Electro-optics	50
Calculating Mathematical Tables	25
Seismological Phenomena of Japan	75
Pellian Equation Tables	15
Electrical Standards	50
Electrolysis	5

B.—*Chemistry.*

Properties of Solutions	10
Analysis of Iron and Steel	10
Isomeric Naphthalene Derivatives	15
Silent Discharge of Electricity	5
Methods of Teaching Chemistry	10
Absorption Spectra	30
Recording the Results of Water Analysis	10
Oxidation of Hydracids in Sunlight	15

C.—*Geology.*

Erratic Blocks	10
Volcanic Phenomena of Vesuvius	20
Fossil Phyllopoda	20
Geological Record	100
Underground Waters	5
Excavations at Oldbury Hill	15
Cretaceous Polyzoa	10
Geological Photographs	10
Lias Beds of Northamptonshire	25

Y

D.—*Biology.*

Botanical Station at Peradeniya	£50
Deep-sea Tow-net	10
Naples Zoological Station	100
West India Islands	100
Marine Biological Association	30

F.—*Economic Science and Statistics.*

Monetary Standard	10
Precious Metals in use as Money	15

G.—*Mechanical Science.*

Waves and Currents in Estuaries	150
Graphic Methods in Mechanical Science	15

H.—*Anthropology.*

North-Western Tribes of Canada	100
Effect of Occupations on Physical Development	20
Anthropological Notes and Queries	50
Anthropometric Calculations	10
Nomad Tribes of Asia Minor	25
Natives of India	10
Corresponding Societies	20
Total	£1265

SECTION C.

GEOLOGY.

Opening Address by Prof. James Geikie, LL.D., F.R.SS. L. & E., F.G.S., President of the Section.

The President of this Section must often have some difficulty in selecting a subject for his address. It is no longer possible to give an interesting and instructive summary of the work done by the devotees of our science during even one year. So numerous have the students of geological science become—so fertile are the fields they cultivate—so abundant the harvests they reap—that one in my present position may well despair of being able to take stock of the numerous additions to our knowledge which have accumulated within the last twelve months. Neither is there any burning question which at this time your President need feel called upon to discuss. True, there are controversies that are likely to remain unsettled for years to come—there are still not a few matters upon which we must agree to differ—we do not yet see eye to eye in all things geological. But experience has shown that as years advance truth is gradually evolved, and old controversies die out; and so doubtless it will continue to be. The day when controversies shall cease, however, is yet, I hope, far in the future; for should that dull and unhappy time ever arrive, it is quite certain that mineralogists, petrologists, palæontologists, and geologists shall have died out of the world. Following the example of many of my predecessors, I shall confine my remarks to certain questions in which I have been specially interested. And in doing so I shall endeavour to steer clear, as far as I can, of controversial matters. My purpose, then, is to give an outline of some of the results obtained during the last few years by Continental workers in the domain of glacial geology.

Those who are not geologists will probably smile when they hear one declare that wielders of the hammer are extremely conservative—that they are slow to accept novel views, and very tenacious of opinions which have once found favour in their eyes. Nevertheless, such is the case; and well for us that it is so. However captivating, however imposing, however strongly supported by evidence a new view may appear to be, we do well to criticize, to sift the evidence, and to call for more facts and experiments, if such are possible, until the proofs become so strong as to approach as near a demonstration as geologists can in most cases expect such proofs to go. The history of our science, and indeed of most sciences, affords abundant illustration of what I say. How many long years were the views of sub-aërial erosion, as taught by Hutton and Playfair, canvassed and controverted before they became accepted! And even after their general soundness had been established, how often have we heard nominal disciples of these fathers of physical geology refuse to go so far as to admit that the river-valleys of our islands have been excavated by epigene agents? If, as a rule, it takes some time for a novel view to gain acceptance, it is equally true that views which have long been held are only with difficulty discarded. Between the new and the old there is a constant struggle for existence, and if the latter should happen to survive, it is only in a modified form. I have often thought that a history of the evolution of geological theories would make a very entertaining and instructive work. We should learn from it, amongst other things, that the advance of our science has not always been continuous—now and again, indeed, it has almost seemed as if the movement had been retrograde. Knowledge has not come in like an overwhelming flood—like a broad majestic river—but rather like a gently-flowing tide, now advancing, now retiring, but ever, upon the whole, steadily gaining ground. The history I speak of would also teach us that many of the general views and hypotheses which have been from time to time abandoned as unworkable are hardly deserving of the reproach and ridicule which we in these latter days may be inclined to cast upon them. As the Scots proverb says, "It is easy to be wise behindhand." It could be readily shown that not a few discarded notions and opinions have frequently worked for good, and have rather stimulated than checked inquiry. Such reflections should be encouraging to every investigator, whether he be a defender of the old or an advocate of the new. Time tries all, and each worker may claim a share in the final establishment of the truth.

Perhaps there is no department of geological inquiry that has given rise to more controversy than that which I have selected for the subject of this address. Hardly a single step in advance has been taken without vehement opposition. But the din of contending sides is not so loud now—the dust of the conflict has to some extent cleared away, and the positions which have been lost or maintained, as the case may be, can be readily discerned. The glacialist who can look back over the last twenty-five years of wordy conflict has every reason to be jubilant and hopeful. Many of those who formerly opposed him have come over to his side. It is true he has not had everything his own way. Some extreme views have been abandoned in the struggle—that of a great Polar ice-sheet, for example, as conceived of by Agassiz. I am not aware, however, that many serious students of glacial geology ever adopted that view. But it was quite an excusable hypothesis, and has been abundantly suggestive. Had Agassiz lived to see the detailed work of these later days, he would doubtless have modified his notion, and come to accept the view of large continental glaciers which has taken its place.

The results obtained by geologists, who have been studying the peripheral areas of the drift-covered regions of our continent, are such as to satisfy us that the drifts of those regions are not iceberg-droppings, as we used to suppose, but true morainic matter and fluvio-glacial detritus. Geologists have not jumped to this conclusion—they have only accepted it after laborious investigation of the evidence. Since Dr. Otto Torell, in 1875, first stated his belief that the "diluvium" of North Germany was of glacial origin, a great literature on the subject has sprung up, a perusal of which will show that with our German friends glacial geology has passed through much the same succession of phases as with us. At first icebergs are appealed to as explaining everything; next we meet with sundry ingenious attempts at a compromise between floating ice and a continuous ice-sheet. As observations multiply, however, the element of floating ice is gradually eliminated, and all the phenomena are explained by means of land-ice and *Schmelz-wasser* alone. It is a remarkable fact that the iceberg hypothesis has always been most strenuously upheld by geologists whose labours have been largely confined to the peripheral areas of drift-covered countries. In the upland and mountainous tracts, on the other hand, that hypothesis has never been able to survive a moderate amount of accurate observation. Even in Switzerland—the land of glaciers—geologists at one time were of opinion that the boulder-clays of the low grounds had a different origin from those which occur in the mountain valleys. Thus it was supposed that at the close of the Pleistocene period the Alps were surrounded by great lakes or gulfs of some inland sea, into which the glaciers of the high valleys flowed and calved their icebergs—these latter scattering erratics and earthy *débris* over the drowned areas. Sartorius von Waltershausen[1] set forth this view in an elaborate and well-illustrated paper. Unfortunately for his hypothesis, no trace of the supposed great lakes or inland sea has ever been detected; on the contrary, the character of the morainic accumulations, and the symmetrical grouping and radiation of the erratics and perched blocks over the foot-hills and low grounds, show that these last have been invaded and overflowed by the glaciers themselves. Even the most strenuous upholders of the efficacy of icebergs as originators of some boulder-clays admit that the boulder-clay or till, of what we may call the inner or central region of a glaciated tract, is the product of land-ice. Under this category comes the boulder-clay of Norway, Sweden, and Finland, and of the Alpine lands of Central Europe, not to speak of the hilly parts of our own islands.

When we come to study the drifts of the peripheral areas it is not difficult to see why these should be considered to have had a different origin. They present certain features which, although not absent from the glacial deposits of the inner region, are not nearly so characteristic of such upland tracts. I refer especially to the frequent interstratification of boulder clays with well-bedded deposits of clay, sand, and gravel; and to the fact that these boulder-clays are often less compressed than those of the inner region, and have even occasionally a silt-like character. Such appearances do seem at first to be readily explained on the assumption that the deposits have been accumulated in water opposite the margin of a continental glacier or ice-sheet; and this was the view which several able investigators in Germany were for some time inclined to adopt.

But when the phenomena came to be studied in greater detail, and over a wider area, this preliminary hypothesis did not prove satisfactory. It was discovered, for example, that "giants' kettles"[2] were more or less commonly distributed under the glacial deposits, and such "kettles" could only have originated at the bottom of a glacier. Again, it was found that preglacial accumulations were plentifully developed in certain places below the drift, and were often involved with the latter in a remarkable way. The "brown-coal formation" in like manner was violently disturbed and displaced, to such a degree that frequently the boulder-clay is found to underlie it. Similar phenomena were encountered in regions where the drift overlies the Chalk—the latter presenting the appearance of having been smashed and shattered—the fragments having often been dragged some distance, so as to form a kind of friction-breccia underlying the drift, while large masses are often included in the clay itself. All the facts pointed to the conclusion that these disturbances were due to tangential thrusting or crushing, and were not the result of vertical displacements, such as are produced by normal faulting, for the disturbances in question die out from above downwards. Evidence of similar thrusting or crushing is seen in the remarkable faults and contortions that so often characterize the clays and sands that occur in the boulder-clay itself. The only agent that could produce the appearances now briefly referred to is land-ice, and we must therefore agree with German geologists that glacier-ice has overflowed all the drift-covered regions of the peripheral area. No evidence of marine action in the formation of the stony clays is forthcoming—not a trace of any sea-beach has been detected. And yet, if these clays had been laid down in the sea during the retreat of the ice-sheet from Germany, surely such evidence as I have indicated ought to be met with. To the best of my knowledge the only particular facts which have been appealed to, as proofs of marine action, are the appearance of bedded deposits in the boulder-clays, and the occasional occurrence in the clays themselves of a sea-shell. But other organic remains are also met with now and again in similar positions, such as mammalian bones and fresh-water shells. All these, however, have been shown to be derivative in their origin—they are just as much erratics as the stones and boulders with which they are associated. The only phenomena, therefore, that the glacialist has to account for are the bedded deposits which occur so frequently in the boulder-clays of the peripheral regions, and the occasional silty and uncompressed character of the clays themselves.

The intercalated beds are, after all, not hard to explain. If we consider for a moment the geographical distribution of the boulder-clays, and their associated aqueous deposits, we shall find a clue to their origin. Speaking in general terms, the stony clays thicken out as they are followed from the mountainous and high-lying tracts to the low ground. Thus they are of inconsiderable thickness in Norway, the higher parts of Sweden, and in Finland, just as we find is the case in Scotland, Northern England, Wales, and the hilly parts of Ireland. Traced south from the uplands of Scandinavia and Finland, they gradually thicken out as the low grounds are approached. Thus in Southern Sweden they reach a thickness of 43 metres or thereabout, and of 80 metres in the northern parts of Prussia, while over the wide low-lying regions to the south they attain a much greater thickness—reaching in Holstein, Mecklenburg, Pomerania, and West Prussia a depth of 120 to 140 metres, and still greater depths in Hanover, Mark Brandenburg, and Saxony. In those regions, however, a considerable portion of the "diluvium" consists, as we shall see presently, of water-formed beds.

The geographical distribution of the aqueous deposits which are associated with the stony clays is somewhat similar. They are very sparingly developed in districts where the boulder-clays are thin. Thus they are either wanting, or only occur sporadically in thin irregular beds, in the high grounds of Northern Europe generally. Further south, however, they gradually acquire more importance until in the peripheral regions of the drift-covered tracts they come to equal and eventually to surpass the boulder-clays in prominence. These latter, in fact, at last cease to appear, and the whole bulk of the "diluvium" along the southern margin of the drift area appears to consist of aqueous accumulations alone.

The explanations of these facts advanced by German geologists are quite in accordance with the views which have long been held by glacialists elsewhere, and have been tersely summed up by Dr. Jentzsch (*Jahrb. d. königl. preuss. geologischen Landesanstalt für* 1884, p. 438). The northern regions, he says, were the feeding-grounds of the inland ice. In those regions melting was at a minimum, while the grinding action of the ice was most effective. Here, therefore, erosion reached its maximum—ground-moraine or boulder-clay being unable to accumulate to any thickness. Further south melting greatly increased, while ground-moraine at the same time tended to accumulate—the conjoint action of glacier-ice and sub-glacial water resulting in the complex drifts of the peripheral area. In the disposition and appearance of the aqueous deposits of the "diluvium" we have evidence of an extensive sub-glacial water-circulation—glacier-mills that gave rise to "giants' kettles"—chains of sub-glacial lakes in which fine clays gathered—streams and rivers that flowed in tunnels under the ice, and whose courses were paved with sand and gravel. Nowhere do German geologists find any evidence of marine action. On the contrary, the dovetailing and interosculation of boulder-clay with aqueous deposits are explained by the relation of the ice to the surface over which it flowed. Throughout the peripheral area it did not rest so continuously upon the ground as was the case in the inner region of maximum erosion. In many places it was tunnelled by rapid streams and rivers, and here and there it arched over sub-glacial lakes, so that accumulation of ground-moraine proceeded side by side with the formation of aqueous sediments. Much of that ground-moraine is of the usual tough and hard-pressed character, but here and there it is somewhat less coherent and even silt-like. Now a study of the ground-moraines of modern glaciers affords us a reasonable explanation of such differences. Dr. Brückner[1] has shown that in many places the ground-moraine of Alpine glaciers is included in the bottom of the ice itself. The ground-moraine, he says, frequently appears as an ice-stratum abundantly impregnated with silt and rock-fragments—it is like a conglomerate or breccia which has ice for its binding material. When this ground-moraine melts out of the ice—no running water being present—it forms a layer of unstratified silt or clay, with stones scattered irregularly through it. Such being the case in modern glaciers, we can hardly doubt that over the peripheral areas occupied by the old northern ice-sheet boulder-clay must frequently have been accumulated in the same way. Nay, when the ground-moraine melted out and dropped here and there into quietly-flowing water it might even acquire in part a bedded character.

The limits reached by the inland ice during its greatest extension are becoming more and more clearly defined, although its southern margin will probably never be so accurately determined

[1] "Untersuchungen über die Klimate der Gegenwart und der Vorwelt," &c. (*Natuurkundige Verhandelingen v. d. Holland. Maatsch. d. Wetensch. te Haarlem*, 1865).

[2] These appear to have been first detected by Prof. Berendt and Prof. E. Geinitz.

[1] "Die Vergletscherung des Salzachgebietes, &c.," *Geographische Abhandlungen herausgegeben v. A. Penck*, Band i. Heft 1.

as that of the latest epoch of general glaciation. The reasons for this are obvious. When the inland ice flowed south to the Harz and the hills of Saxony, it formed no great terminal moraines. Doubtless many erratics and much rock-rubbish were showered upon the surface of the ice from the higher mountains of Scandinavia, but owing to the fanning-out of the ice on its southward march, such superficial *débris* was necessarily spread over a constantly widening area. It may well be doubted, therefore, whether it ever reached the terminal front of the ice-sheet in sufficient bulk to form conspicuous moraines. It seems most probable that the terminal moraines of the great inland ice would consist of low banks of boulder-clay and aqueous materials—the latter, perhaps, strongly predominating, and containing here and there larger and smaller angular erratics which had travelled on the surface of the ice. However that may be, it is certain that the whole region in question has been considerably modified by subsequent denudation, and to a large extent is now concealed under deposits belonging to later stages of the Pleistocene period. The extreme limits reached by the ice are determined rather by the occasional presence of rock-striæ and *roches moutonnées*, of boulder-clay and northern erratics, than by recognizable terminal moraines. The southern limits reached by the old inland ice appear in this way to have been tolerably well ascertained over a considerable portion of Central Europe. Some years ago I published a small sketch-map ("Prehistoric Europe," 1881) showing the extent of surface formerly covered by ice. On this map I did not venture to draw the southern margin of the ice-sheet in Belgium further south than Antwerp, where northern erratics were known to occur; but the more recent researches of Belgian geologists show that the ice probably flowed south for some little distance beyond Brussels (see a paper by M. E. Delvaux, *Ann. de la Soc. géol. de Belg.*, t. xiii. p. 158). Here and there in other parts of the Continent the southern limits reached by the northern drift have also been more accurately determined, but, so far as I know, none of these later observations involves any serious modification of the sketch-map referred to.

I have now said enough, however, to show that the notion of a general ice-sheet having covered so large a part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral areas of the "great northern drift." And perhaps I may be allowed to express my own belief that the drifts of Middle and Southern England, which exhibit the same complexity as the "lower diluvium" of the Continent, will eventually be generally acknowledged to have had a similar origin. I have often thought that whilst politically we are happy in having the sea all round us, geologically we should have gained perhaps by its greater distance. At all events we should have been less ready to invoke its assistance to explain every puzzling appearance presented by our glacial accumulations.

I now pass on to review some of the general results obtained by Continental geologists as to the extent of area occupied by inland ice during the last great extension of glacier-ice in Europe. It is well-known that this latest ice-sheet did not overflow nearly so wide a region as that underneath which the lowest boulder-clay was accumulated. This is shown not only by the geographical distribution of the youngest boulder-clay, but by the direction of rock-striæ, the trend of erratics, and the position of well-marked moraines. Gerard de Geer has given a summary (*Zeitschrift d. deutsch. geolog. Ges.*, Bd. xxxvii. p. 177) of the general results obtained by himself and his fellow-workers in Sweden and Norway; and these have been supplemented by the labours of Berendt, Geinitz, Hunchecorne, Keilhack, Klockmann, Schröder, Wahnschaffe, and others in Germany, and by Sederholm in Finland.[1] From them we learn that the end-moraines of the ice circle round the southern coasts of Norway, from whence they sweep south-east by east across the province of Gottland in Sweden, passing through the lower ends of Lakes Wener and Wetter, while similar moraines mark out for us the terminal front of the inland ice in Finland—at least two parallel frontal moraines passing inland from Hango Head on the Gulf of Finland through the southern part of that province to the north of Lake Ladoga. Further north-east than this they have not been traced; but, from some observations by Helmersen, Sederholm thinks it probable that the terminal ice-front extended north-east by the north of Lake Onega to the eastern shores of the White Sea. Between Sweden and Finland lies the basin of the Baltic, which at the period in question was filled with ice, forming a great Baltic glacier, which overflowed the Åland Islands, Gottland, and Öland, and which, fanning-out as it passed towards the south-west, invaded, on the south side, the Baltic provinces of Germany, while, on the north, it crossed the southern part of Scania in Sweden and the Danish islands to enter upon Jutland.

The upper boulder-clay of those regions is now recognized as the ground-moraine of this latest ice-sheet. In many places it is separated from the older boulder-clay by interglacial deposits, some of which are marine, while others are of fresh-water and terrestrial origin. During interglacial times the sea that overflowed a considerable portion of North Germany was evidently continuous with the North Sea, as is shown not only by the geographical distribution of the interglacial marine deposits, but by their North Sea fauna. German geologists generally group all the interglacial deposits together, as if they belonged to one and the same interglacial epoch. This perhaps we must look upon as only a provisional arrangement. Certain it is that the fresh-water and terrestrial beds which frequently occur on the same or a lower level, and at no great distance from the marine deposits, cannot in all cases be contemporaneous with the latter. Possibly, however, such discordances may be accounted for by oscillations in the level of the interglacial sea—land and water having alternately prevailed over the same area. Two boulder-clays, as we have seen, have been recognized over a wide region in North Germany. In some places, however, three or more such boulder-clays have been observed overlying one another throughout considerable areas, and these clays are described as being distinctly separate and distinguishable the one from the other.[1] Whether they with their intercalated aqueous deposits indicate great oscillations of one and the same ice-sheet—now advancing, now retreating—or whether the stony clays may not be the ground-moraines of so many different ice-sheets, separated the one from the other by true interglacial conditions, future investigations must be left to decide.

The general conclusions arrived at by those who are at present investigating the glacial accumulations of Northern Europe may be summarized as follows:—

1. Before the invasion of Northern Germany by the inland ice the low grounds bordering on the Baltic were overflowed by a sea which contained a boreal and arctic fauna. These marine conditions are indicated by the presence under the lower boulder-clay of more or less well-bedded fossiliferous deposits. On the same horizon occur also beds of sand, containing fresh-water shells, and now and again mammalian remains, some of which imply cold and others temperate climatic conditions. Obviously all these deposits may pertain to one and the same period, or more properly to different stages of the same period—some dating back to a time when the climate was still temperate, while others clearly indicate the prevalence of cold conditions, and are therefore probably somewhat younger.

2. The next geological horizon in ascending order is that which is marked by the "lower diluvium"—the glacial and fluvio-glacial detritus of the great ice-sheet which flowed south to the foot of the Harz Mountains. The boulder clay on this horizon now and again contains marine, fresh-water, and terrestrial organic remains, derived undoubtedly from the so-called preglacial beds already referred to. These latter, it would appear, were ploughed up and largely incorporated with the old ground-moraine.

3. The interglacial beds which next succeed contain remains of a well-marked temperate fauna and flora, which point to something more than a mere partial or local retreat of the inland ice. The geographical distribution of the beds and the presence in these of such forms as *Elephas antiquus*, *Cervus elephas*, *C. megaceros*, and a flora comparable to that now existing in Northern Germany, justify geologists in concluding that the interglacial epoch was one of long duration, and characterized in Germany by climatic conditions apparently not less temperate than those that now obtain. One of the phases of that interglacial epoch, as we have seen, was the overflowing of the Baltic provinces by the waters of the North Sea.

4. To this well-marked interglacial epoch succeeded another epoch of arctic conditions, when the Scandinavian inland ice

[1] For papers by Berendt and his associates see especially the *Jahrbuch d. k. preuss. geol. Landesanstalt*, and the *Zeitschr. d. deutsch. geol. Ges.* for the past few years. Geinitz, *Forsch. z. d. Landes- u. Volkskunde*, i. 5; *Leopoldina*, xxii. p. 37; *I. Beitrag z. Geologie Mecklenburgs*, 1880, pp. 46, 56. Sederholm, *Fennia*, i. No. 7.

[1] H. Schröder, *Jahrb. d. k. preuss. geol. Landesanstalt für* 1887, p. 360.

once more invaded Germany, ploughing through the interglacial deposits, and working these up in its ground-moraine. So far as I can learn, the prevalent belief among geologists in North Germany is that there was only one interglacial epoch; but, as already stated, doubt has been expressed whether all the facts can be thus accounted for. There must always be great difficulty in the correlation of widely-separated interglacial deposits, and the time does not seem to me to have yet come when we can definitely assert that all those interglacial beds belong to one and the same geological horizon.

I have dwelt upon the recent work of geologists in the peripheral areas of the drift-covered regions of Northern Europe, because I think the results obtained are of great interest to glacialists in this country. And for the same reason I wish next to call attention to what has been done of late years in elucidating the glacial geology of the Alpine lands of Central Europe —and more particularly of the low grounds that stretch out from the foot of the mountains. Any observations that tend to throw light upon the history of the complex drifts of our own peripheral areas cannot but be of service. It is quite impossible to do justice in this brief sketch to the labours of the many enthusiastic geologists who, within recent years, have increased our knowledge of the glaciation of the Alpine lands. At present, however, I am not so much concerned with the proofs of general glaciation as with the evidence that goes to show how the Alpine ground-moraines have been formed, and with the facts which have led certain observers to conclude that the Alps have endured several distinct glaciations within Pleistocene times. Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low grounds beyond, are of true glacial origin. Now these ground-moraines are closely similar to the boulder-clays of this country and Northern Europe. Like them, they are frequently tough and hard-pressed, but now and again somewhat looser and less firmly coherent. Frequently also they contain lenticular beds, and more or less thick sheets of aqueous deposits—in some places the stony clays even exhibiting a kind of stratification—and ever and anon such water-assorted materials are commingled with stony clay in the most complex manner. These latter appearances are, however, upon the whole best developed upon the low grounds that sweep out from the base of the Alps. The only question concerning the ground-moraines that has recently given rise to much discussion is the origin of the materials themselves. It is obvious that there are only three possible modes in which those materials could have been introduced to the ground-moraine: either they consist of superficial morainic *débris* which has found its way down to the bottom of the old glaciers by crevasses; or they may be made up of the rock-rubbish, shingle, gravel, &c., which doubtless strewed the valleys before these were occupied by ice; or, lastly, they may have been derived in chief measure from the underlying rocks themselves by the action of the ice that overflowed them. The investigations of Penck, Blaas, Böhm, and Brückner appear to me to have demonstrated that the ground-moraines are composed mostly of materials which have been detached from the underlying rocks by the erosive action of the glaciers themselves. Their observations show that the regions studied by them in great detail were almost completely buried under ice, so that the accumulation of superficial moraines was for the most part impossible; and they advance a number of facts which prove positively that the ground-moraines were formed and accumulated under ice. I cannot here recapitulate the evidence, but must content myself by a reference to the papers in which this is fully discussed.[1] These geologists do not deny that some of the material may occasionally have come from above, nor do they doubt that pre-existing masses of rock-rubbish and alluvial accumulations may have been incorporated with the ground-moraines; but the enormous extent of the latter, and the direction of transport and distribution of the erratics which they contain cannot be thus accounted for, while all the facts are readily explained by the action of the ice itself, which used its sub-glacial *débris* as tools with which to carry on the work of erosion.

Prof. Heim and others have frequently asserted that glaciers have little or no eroding power, since at the lower ends of existing glaciers we find no evidence of such erosion being in operation. But the chief work of a glacier cannot be carried on at its lower end, where motion is reduced to a minimum, and where the ice is perforated by sub-glacial tunnels and arches, underneath which no glacial erosion can possibly take place; and yet it is upon observations made in just such places that the principal arguments against the erosive action of glaciers have been based. If all that we could ever know of glacial action were confined to what we can learn from peering into the grottoes at the terminal fronts of existing glaciers, we should indeed come to the conclusion that glaciers do not erode their rocky beds to any appreciable extent. But as we do not look for the strongest evidence of fluviatile erosion at the mouth of a river, but in its valley- and mountain-tracks, so if we wish to learn what glacier-ice can accomplish, we must study in detail some wide region from which the ice has completely disappeared. When this plan has been followed, it has happened that some of the strongest opponents of glacial erosion have been compelled by the force of the evidence to go over to the other camp. Dr. Blaas, for example, has been led by his observations on the glacial formations of the Inn Valley to recant his former views, and to become a formidable advocate of the very theory which he formerly opposed. To his work and the memoirs by Penck, Brückner, and Böhm already cited, and especially to the admirable chapter on glacier-erosion by the last-named author, I would refer those who may be anxious to know the last word on this much-debated question.

The evidence of interglacial conditions within the Alpine lands continues to increase. These are represented by alluvial deposits of silt, sand, gravel, conglomerate, breccia, and lignites. Penck, Böhm, and Brückner find evidence of two interglacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. No mere temporary retreat and re-advance of the glaciers, according to them, will account for the phenomena presented by the interglacial deposits and associated morainic accumulations. During interglacial times the glaciers disappeared from the lower valleys of the Alps—the climate was temperate, and probably the snow-fields and glaciers approximated in extent to those of the present day. All the evidence conspires to show that an interglacial epoch was of prolonged duration. Dr. Brückner has observed that the moraines of the last glacial epoch rest here and there upon löss, and he confirms Penck's observations in South Bavaria that this remarkable formation never overlies the morainic accumulations of the latest glacial epoch. According to Penck and Brückner, therefore, the löss is of interglacial age. There can be little doubt, however, that löss does not belong to any one particular horizon. Wahnschaffe[1] and others have shown that throughout wide areas in North Germany it is the equivalent in age of the "upper diluvium," while Schumacher (*Hygienische Topographie von Strassburg i. E.*, 1885) points out that in the Rhine Valley it occurs on two separate and distinct horizons. Prof. Andreæ has likewise shown (*Abhandl. z. geol. Specialkarte v. Elsass-Lothringen*, Bd. vii. Heft 2) that there is an upper and lower löss in Alsace, each characterized by its own special fauna.

There is still considerable difference of opinion as to the mode of formation of this remarkable accumulation. By many it is considered to be an aqueous deposit; others, following Richthofen, are of opinion that it is a wind-blown accumulation; while some incline to the belief that it is partly the one and partly the other. Nor do the upholders of these various hypotheses agree amongst themselves as to the precise manner in which water or wind has worked to produce the observed results. Thus, amongst the supporters of the aqueous origin of the löss, we find this attributed to the action of heavy rains washing over and rearranging the material of the boulder-clays (Laspeyres, *Erläuterungen z. geol. Specialkarte v. Preussen*, &c., *Blatt Gröbzig, Zörbig, und Petersberg*). Many, again, have held it probable that the löss is simply the finest loam distributed over the low grounds by the flood-waters that escaped from the northern inland ice and the *mers de glace* of the Alpine lands of Central Europe. Another suggestion is that much of the material of the löss may have been derived from the denudation of the boulder-clays by flood-water, during the closing stages of the last cold period. It is pointed out that in some regions at least the löss is underlain by a layer of erratics, which are believed to be the residue of the denuded boulder-clay.

[1] Penck, "Die Vergletscherung der deutschen Alpen." Blaas, "Zeitschr. d. Ferdinandeums," 1885. Böhm, *Jahr. d. k. k. geol. Reichsanstalt*, 1885, Bd. xxxv. Heft 3. Brückner, "Die Vergletscherung d. Salzachgebietes," &c., 1886

[1] *Abhandl. z. geol. Specialkarte v. Preussen*, &c., Bd. vii. Heft 1; *Zeitschr. d. deutsch. geol. Gesellsch.* 1885, p. 904; 1886, p. 367.

We are reminded by Klockmann (*Jahrb. d. k. preuss. geol. Landesanstalt für* 1883, p. 262) and Wahnschaffe (*op. cit.*, and *Zeitschr. d. deutsch. geol. Ges.* 1886, p. 367) that the inland ice must have acted as a great dam, and that wide areas in Germany, &c., would be flooded, partly by water derived from the melting inland ice, and partly by waters flowing north from the hilly tracts of Middle Germany. In the great basins thus formed there would be a commingling of fine silt-material derived from north and south, which would necessarily come to form a deposit having much the same character throughout.

From what I have myself seen of the löss in various parts of Germany, and from all that I have gathered from reading and in conversation with those who have worked over löss-covered regions, I incline to the opinion that löss is for the most part of aqueous origin. In many cases this can be demonstrated, as by the occurrence of bedding and the intercalation of layers of stones, sand, gravel, &c., in the deposit; again, by the not infrequent appearance of fresh-water shells; but, perhaps, chiefly by the remarkable uniformity of character which the löss itself displays. It seems to me reasonable also to believe that the flood-waters of glacial times must needs have been highly charged with finely-divided sediment, and that such sediment would be spread over wide regions in the low grounds—in the slack-waters of the great rivers, and in the innumerable temporary lakes which occupied, or partly occupied, many of the valleys and depressions of the land. There are different kinds of löss or löss like deposits, however, and all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of boulder-clay. Possibly, also, some löss may owe its origin to the action of rain upon the stony clays, producing what we in this country would call "rain-wash." There are other accumulations, however, which no aqueous theory will satisfactorily explain. Under this category comes much of the so-called *Berglöss*, with its abundant land-shells, and its generally unstratified character. It seems likely that such löss is simply the result of sub-aërial action, and owes its origin to rain, frost, and wind acting upon the superficial formations, and rearranging their finer-grained constituents. And it is quite possible that the upper portion of much of the löss of the lower grounds may have been re-worked in the same way. But I confess I cannot yet find in the facts adduced by German geologists any evidence of a dry-as-dust epoch having obtained in Europe during any stage of the Pleistocene period. The geographical position of our continent seems to me to forbid the possibility of such climatic conditions, while all the positive evidence we have points rather to humidity than dryness as the prevalent feature of Pleistocene climates. It is obvious, however, that after the flood-waters had disappeared from the low grounds of the Continent, sub-aërial action would come into play over the wide regions covered by glacial and fluvio-glacial deposits. Thus, in the course of time, these deposits would become modified,—just as similar accumulations in these islands have been top-dressed, as it were, and to some extent even rearranged. I am strengthened in these views by the conclusions arrived at by M. Falsan, the eminent French glacialist. Covering the plateaux of the Dombs, and widely spread throughout the valleys of the Rhone, the Ain, the Isère, &c., in France, there is a deposit of löss, he says, which has been derived from the washing of the ancient moraines. At the foot of the Alps, where black schists are largely developed, the löss is dark grey; but west of the secondary chain the same deposit is yellowish, and composed almost entirely of siliceous materials, with only a very little carbonate of lime. This *limon* or löss, however, is very generally modified towards the top by the chemical action of rain, the yellow löss acquiring a red colour. Sometimes it is crowded with calcareous concretions; at other times it has been deprived of its calcareous element and converted into a kind of pulverulent silica or quartz. This, the true löss, is distinguished from another *lehm*, which Falsan recognizes as the product of atmospheric action—formed, in fact, in place, from the disintegration and decomposition of the subjacent rocks. Even this *lehm* has been modified by running water—dispersed or accumulated locally, as the case may be (Falsan, "La Période glaciaire," p. 81).

All that we know of the löss and its fossils compels us to include this accumulation as a product of the Pleistocene period. It is not of postglacial age—even much of what one may call the "remodified löss" being of Late Glacial or Pleistocene age. I cannot attempt to give here a summary of what has been learned within recent years as to the fauna of the löss. The researches of Nehring and Liebe have familiarized us with the fact that at some particular stage in the Pleistocene period a fauna like that of the alpine steppe-lands of Western Asia was indigenous to Middle Europe, and the recent investigations of Woldřich have increased our knowledge of this fauna. At what horizon, then, does this steppe-fauna make its appearance? At Thiede, Dr. Nehring discovered in so-called löss three successive horizons, each characterized by a special fauna. The lowest of these faunas was decidedly arctic in type; above that came a steppe-fauna, which last was succeeded by a fauna comprising such forms as mammoth, woolly rhinoceros, *Bos*, *Cervus*, horse, hyæna, and lion. Now, if we compare this last fauna with the forms which have been obtained from true postglacial deposits—those deposits, namely, which overlie the younger boulder-clays and flood-accumulations of the latest glacial epoch—we find little in common. The lion, the mammoth, and the rhinoceros are conspicuous by their absence from the postglacial beds of Europe. In place of them we meet with a more or less arctic fauna, and a high-alpine and arctic flora, which, as we all know, eventually gave place to the flora and fauna with which Neolithic man was contemporaneous. As this is the case throughout North-Western and Central Europe, we seem justified in assigning the Thiede beds to the Pleistocene period, and to that interglacial stage which preceded and gradually merged into the last glacial epoch. That the steppe-fauna indicates relatively drier conditions of climate than obtained when perennial snow and ice covered wide areas of the low ground goes without saying; but I am unable to agree with those who maintain that it implies a dry-as-dust climate, like that of some of the steppe-regions of our own day. The remarkable commingling of arctic and steppe-faunas discovered by Woldřich in the Böhmerwald (*Sitzungsb. d. kais. Akad. d. W. math. nat. Cl.*, 1880, p. 7; 1881, p. 177; 1883, p. 978) shows, I think, that the jerboas, marmots, and hamster-rats were not incapable of living in the same regions contemporaneously with lemmings, arctic hares, Siberian social voles, &c. But when a cold epoch was passing away the steppe-forms probably gradually replaced their arctic congeners, as these migrated northwards during the continuous amelioration of the climate.

If the student of the Pleistocene faunas has certain advantages in the fact that he has to deal with forms many of which are still living, he labours at the same time under disadvantages which are unknown to his colleagues who are engaged in the study of the life of far older periods. The Pleistocene period was distinguished above all things by its great oscillations of climate—the successive changes being repeated, and producing correlative migrations of floras and faunas. We know that arctic and temperate faunas and floras flourished during interglacial times, and a like succession of life-forms followed the final disappearance of glacial conditions. A study of the organic remains met with in any particular deposit will not necessarily, therefore, enable us to assign these to their proper horizon. The geographical position of the deposit, and its relation to Pleistocene accumulations elsewhere must clearly be taken into account. Already, however, much has been done in this direction, and it is probable that ere long we shall be able to arrive at a fair knowledge of the various modifications which the Pleistocene floras and faunas experienced during that protracted period of climatic changes of which I have been speaking. We shall even possibly learn how often the arctic, steppe-, prairie-, and forest-faunas, as they have been defined by Woldřich, replaced each other. Even now some approximation to this better knowledge has been made. Dr. Pohlig,[1] for example, has compared the remains of the Pleistocene faunas obtained at many different places in Europe, and has presented us with a classification which, although confessedly incomplete, yet serves to show the direction in which we must look for further advances in this department of inquiry.

During the last twenty years the evidence of interglacial conditions both in Europe and America has so increased that geologists generally no longer doubt that the Pleistocene period was characterized by great changes of climate. The occurrence at many different localities on the Continent of beds of lignite and fresh-water alluvia, containing remains of Pleistocene Mammalia, intercalated between separate and distinct boulder-clays, has

[1] Pohlig. *Sitzungsb. d. Niederrheinischen Gesellschaft zu Bonn*, 1884; *Zeitschr. d. deutsch. geolog. Ges.*, 1887, p 798. For a very full account of the diluvial European and Northern Asiatic mammalian faunas by Woldřich, see *Mém. de l'Acad. des Sciences de St. Pétersbourg*, Sér. vii, t. xxxv., 1887.

left us no alternative. The interglacial beds of the Alpine lands of Central Europe are paralleled by similar deposits in Britain, Scandinavia, Germany, and France. But opinions differ as to the number of glacial and interglacial epochs, many holding that we have evidence of only two cold stages and one general interglacial stage. This, as I have said, is the view entertained by most geologists who are at work on the glacial accumulations of Scandinavia and North Germany. On the other hand, Dr. Penck and others, from a study of the drifts of the German Alpine lands, believe that they have met with evidence of three distinct epochs of glaciation, and two epochs of interglacial conditions. In France, while some observers are of opinion that there have been only two epochs of general glaciation, others, as, for example, M. Tardy, find what they consider to be evidence of several such epochs. Others, again, as M. Falsan, do not believe in the existence of any interglacial stages, although they readily admit that there were great advances and retreats of the ice during the Glacial period. M. Falsan, in short, believes in oscillations, but is of opinion that these were not so extensive as others have maintained. It is, therefore, simply a question of degree, and whether we speak of oscillations or of epochs, we must needs admit the fact that throughout all the glaciated tracts of Europe, fossiliferous deposits occur intercalated among glacial accumulations. The successive advance and retreat of the ice, therefore, was not a local phenomenon, but characterized all the glaciated areas. And the evidence shows that the oscillations referred to were on a gigantic scale.

The relation borne to the glacial accumulations by the old river alluvia which contain relics of palæolithic man early attracted attention. From the fact that these alluvia in some places overlie glacial deposits, the general opinion (still held by some) was that palæolithic man must needs be of postglacial age. But since we have learned that all boulder-clay does not belong to one and the same geological horizon—that, in short, there have been at least two, and probably more, epochs of glaciation—it is obvious that the mere occurrence of glacial deposits underneath palæolithic gravels does not prove these latter to be postglacial. All that we are entitled in such a case to say is simply that the implement-bearing beds are younger than the glacial accumulations upon which they rest. Their horizon must be determined by first ascertaining the relative position in the glacial series of the underlying deposits. Now, it is a remarkable fact that the boulder-clays which underlie such old alluvia belong, without exception, to the earlier stages of the Glacial period. This has been proved again and again, not only for this country but for Europe generally. I am sorry to reflect that some twenty years have now elapsed since I was led to suspect that the palæolithic gravels and cave-deposits were not of postglacial but of glacial and interglacial age. In 1871–72 I published a series of papers in the *Geological Magazine*, in which were set forth the views I had come to form upon this interesting question. In these papers it was maintained that the alluvial and cave-deposits could not be of postglacial age, but must be assigned to preglacial and interglacial times, and in chief measure to the latter. Evidence was led to show that the latest great development of glacier-ice in Europe took place after the southern pachyderms and palæolithic man had vacated England; that during this last stage of the Glacial period man lived contemporaneously with a northern and alpine fauna in such regions as Southern France; and lastly, that palæolithic man and the southern Mammalia never revisited North-Western Europe after extreme glacial conditions had disappeared. These conclusions were arrived at after a somewhat detailed examination of all the evidence then available, the remarkable distribution of the palæolithic and ossiferous alluvia having, as I have said, particularly impressed me. I coloured a map to show at once the areas covered by the glacial and fluvio-glacial deposits of the last glacial epoch, and the regions in which the implement-bearing and ossiferous alluvia had been met with, when it became apparent that the latter never occurred at the surface within the regions occupied by the former. If ossiferous alluvia did here and there appear within the recently glaciated areas, it was always either in caves, or as infra- or interglacial deposits. Since the date of these researches our knowledge of the geographical distribution of Pleistocene deposits has greatly increased, and implements and other relics of palæolithic man have been recorded from many new localities throughout Europe. But none of this fresh evidence contradicts the conclusions I had previously arrived at; on the contrary, it has greatly strengthened my general argument.

Prof. Penck was, I think, the first on the Continent to adopt the views referred to. He was among the earliest to recognize the evidence of interglacial conditions in the drift-covered regions of Northern Germany, and it was the reflections which those remarkable interglacial beds were so well calculated to suggest that led him into the same path as myself. Dr. Penck has published a map (*Archiv für Anthropologie*, Bd. xv., Heft 3, 1884) showing the areas covered by the earlier and later glacial deposits in Northern Europe and the Alpine lands, and indicating at the same time the various localities where palæolithic finds have occurred. And in not a single case do any of the latter appear within the areas covered by the accumulations of the last glacial epoch.

A glance at the papers which have been published in Germany within the last few years will show how greatly students of the Pleistocene ossiferous beds have been influenced by what is now known of the interglacial deposits and their organic remains Profs. Rothpletz (*Denkschrift d. schweizer. Ges. für d. gesammt. Nat.*, Bd. xxviii., 1881) and Andreæ (*Abhandl. z. geolog. Specialkarte v. Elsass-Lothringen*, Bd. iv., Heft 2, 1884), Dr. Pohlig (*op. cit.*) and others, do not now hesitate to correlate with those beds the old ossiferous and implement-bearing alluvia which lie altogether outside of glaciated regions.

The relation of the Pleistocene alluvia of France to the glacial deposits of that and other countries has been especially canvassed. Rothpletz, in the paper cited above, includes these alluvia amongst the interglacial deposits; and in the present year we have an interesting essay on the same subject by the accomplished secretary of the Anthropological and Archæological Congress, which met last month in Paris. M. Boule correlates (*Revue d'Anthropologie*, 1889, t. i.) the palæolithic cave- and river-deposits of France with those of other countries, and shows that they must be of interglacial age. His classification, I am gratified to find, does not materially differ from that given by myself a number of years ago. He is satisfied that in France there is evidence of three glacial epochs and two well-marked interglacial horizons. The oldest of the palæolithic stages of Mortillet (CHELLÉENNE) culminated, according to Boule, during the last interglacial epoch, while the more recent palæolithic stages (MOUSTÉRIENNE, SOLUTRÉENNE, and MAGDALÉNIENNE) coincided with the last great development of glacier-ice. The palæolithic age, so far as Europe is concerned, came to a close during this last cold phase of the Glacial period.

There are many other points relating to glacial geology which have of late years been canvassed by Continental workers, but these I cannot discuss here. I have purposely, indeed, restricted my remarks to such parts of a wide subject as I thought might have interest for glacialists in this country, some of whom may not have had their attention directed to the results which have recently been attained by their fellow-labourers in other lands. Had time permitted I should gladly have dwelt upon the noteworthy advances made by our American brethren in the same department of inquiry. Especially should I have wished to direct attention to the remarkable evidence adduced in favour of the periodicity of glacial action. Thus Messrs. Chamberlin and Salisbury, after a general review of that evidence, maintain that the Ice Age was interrupted by one chief interglacial epoch, and by three interglacial sub-epochs or episodes of deglaciation. The same authors discuss at some length the origin of the löss, and come to the general conclusion that while deposits of this character may have been formed at different stages of the Glacial period, and under different conditions, yet that upon the whole they are best explained by aqueous action. Indeed a perusal of the recent geological literature of America shows a close accord between the theoretical opinions of many Transatlantic and European geologists.

Thus as years advance the picture of Pleistocene times becomes more and more clearly developed. The conditions under which our old palæolithic predecessors lived—the climatic and geographical changes of which they were the witnesses—are gradually being revealed with a precision that only a few years ago might well have seemed impossible. This of itself is extremely interesting, but I feel sure that I speak the conviction of many workers in this field of labour when I say that the clearing up of the history of Pleistocene times is not the only end which they have in view. One can hardly doubt that when the conditions of that period and the causes which gave rise to these have been more fully and definitely ascertained we shall have advanced some way towards the better understanding of the climatic conditions of still earlier periods. For it cannot be denied that our knowledge of Palæozoic, Mesozoic, and even early Cainozoic climates is unsatisfactory. But we may look forward to the time when much of this uncertainty will disappear. Meteorologists are every day acquiring a clearer conception of the distribution of atmospheric pressure and temperature, and the causes by which that distribution is determined, and the day is coming when we shall be better able than we are now to apply this extended meteorological knowledge to the explanation of the climates of former periods in the world's history. One of the chief factors in the present distribution of atmospheric temperature and pressure is doubtless the relative position of the great land and water areas; and if this be true of the present, it must be true also of the past. It would almost seem, then, as if all one had to do to ascertain the climatic condition of any particular period was to prepare a map, depicting with some approach to accuracy the former relative position of land and sea. With such a map could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now, there is no period in the past history of our globe the geographical conditions of which are better known than the Pleistocene. And yet when we have indicated these upon a map we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptional factor was at work to produce the recognized results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? We all know that various answers have been given to such questions. Whether amongst these the correct solution of the enigma is to be found time will show. Meanwhile, as all hypothesis and theory must starve without facts to feed on, it behoves us as working geologists to do our best to add to the supply. The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelops the question of geological climates.

SECTION E.

GEOGRAPHY.

Opening Address by Colonel Sir Francis de Winton, K.C.M.G., F.R.G.S., President of the Section.

Geography has not inaptly been defined as "the science of distributions," and from whatever aspect we view it, whether from a large and comprehensive basis embracing all the conditions which surround it as a science, or from the narrower limits of simple physiography, we find certain well-defined principles, or one may term them natural laws, pervading everywhere, whose actions have, through their influences on the past, created the present, and according to the uses we now put them must largely govern the future.

The formation of our globe, unfolded to our vision by scientific discovery, brings us face to face with Nature in all her awful grandeur; and we learn how, under a beneficent and all-wise Providence, this world has been fashioned and made for the use of man during periods of time almost beyond man's calculations; and in the history of man upon earth—a mere drop in this ocean of time—we read of the rise and fall of nations, of great wars, of the discoveries of new routes (so ably described by my friend and talented predecessor in the address delivered by him in Section E last year), and we see what large and important developments have taken place as regards the commerce and trade of the world by the effect of these influences; and then, turning to more recent days, we enter upon the discovery of steam, and its application as a motive power,—a discovery which has given rise to extraordinary changes—changes by which the whole trade of the world and its industries have been stimulated and promoted. Add to this the inventions in electricity, by which almost instantaneous communication has been established to all parts of the globe, and we may well cease to wonder at the increase that has been manifested in what may be termed the motive power of the world, and the development of its larger activities.

Still the natural laws which govern this globe, in their relation to the science of geography, remain the same. It matters not how rapidly you travel from the pole to the equator, you will freeze at the one and perspire at the other; and while passing through the different zones of temperature lying between these regions—the frigid, temperate, and torrid zones—you will find each with its own products, varying with climate, soil, and peculiarity of position, and these variations pervade the whole realm of Nature. Take man as an example: with all his power of brain and reason, he is largely subject to his environment. Look at the toiling millions of the temperate zone, and the enormous activity they display, both mental and physical. Note their colour, form, nervous development; and then pass into the tropics, and the whole creature is changed: he is different in colour, and displays none of the energy or brain-power of the white species of his kind. Why is this? It is chiefly due to the environment in which the creature is living.

The effect of climate upon race is somewhat remarkably illustrated in recent times by noticing the physique and nerve-power of the present race of Americans. The wonderful tide of emigration which has raised them to being a nation of 60,000,000 people may have exercised certain influences as regards this change; but there are many true Americans still in existence. Two hundred years ago they were the same race as ourselves, but the difference between us now is marked. The climate of America has given them an individual stamp, and a perceptible difference in outward semblance has shown itself even in this short space of time.

Similar changes are manifested throughout the whole animal and vegetable kingdom; and while the geologist, zoologist, botanist, ethnologist, and entomologist, each and all are separate branches of science, yet each and all have a common ground in geography and its application to the shape and form of land and sea; to the wrinkled folds of the earth's surface which we call mountains and valleys; to the mighty ocean with its currents of air and water, and the influences they exert; to the huge inland seas and lakes; to the great rivers and small streams; to the endless varieties in the animal and vegetable kingdoms; and we find these great elements of Nature contributing each in its own sphere to questions relating to the commerce of the world and the development of new countries.

In this brief introduction to my paper I have designedly, though very briefly, drawn your attention to the science of applied geography before passing in review the most recent explorations and discoveries of the present day; and while doing this, I shall endeavour to draw attention to the great necessity for a more thorough study of this science, and the influences it exerts upon trade and commerce, as we gain a better knowledge of the products of one country and the industries of another, as well as the importance of such knowledge to the great manufacturing centres of this nation as new countries are discovered and developed.

It must be remembered that we no longer enjoy a monopoly of trade. Other nations are exhibiting large commercial activities; and if we desire a continuance of the trade of Great Britain we must put our shoulders to the wheel with the same energies and creative power that have produced such astonishing results during the present century.

In the paper to which I have already alluded, it was clearly shown how largely the rise and fall of the great emporiums of commerce in past centuries were influenced by the struggle for the Eastern trade. This struggle is still going on. The Russians in Central Asia are steadily advancing as each year goes by, and developing that system of absorption which has characterized their policy, especially in that region. Central Asia is the chosen field of their explorers, and the recent decease of General Prjevalsky has been a great loss in the scientific world. A full account of his remarkable discoveries and explorations appeared in the Proceedings of the Royal Geographical Society.

The principal work accomplished by the latest Russian explorers, Messrs. Grombchevski, Mr. Lidsky, and Mr. Grum-Grijmailo, in Central Asia have been in the region of the Pamir, and from thence across the Hindu Kush into Hunza. Also in Eastern Bokhara and in the upper waters of the Yarkand River, the Kalik Pass, and Kanjat. In the prosecution of these researches, which are all dangerously near our Indian frontier, very full reports are made, more especially as regards trade and commerce; and there is no doubt, since the completion of the Transcaspian railway to Samarcand, a great impetus has been given to Russian trade in Central Asia, even extending, by well-known routes, as far as the north-west provinces of China, where Russian goods are now found entering into competition with those of English manufacture.

By means of this railway, right into the heart of Asia, Russia has obtained the trade of a vast area, which formerly passed entirely through British hands. Both politically and commercially she is our rival in the East, and the question which nation is to be supreme must come sooner or later.

There is no more interesting country in the world than China. Her teeming and industrial population, her large mercantile centres, the geographical situation of her territory, her undeveloped mineral wealth, her individuality, and the magnitude of her trade with this country, all combine to invest her with a peculiar importance as regards our mercantile community. Coal has been discovered in all the seventeen provinces of the Chinese Empire, but the passive resistance offered by her rulers and her peoples to all attempts by foreign nations to obtain a footing in the interior have prevented any development of her resources. The day, however, cannot be far distant when railways, some of which are already projected, will open up the interior of China and make her better known; but we should be unworthy children of our forefathers if we permit the trade of this rich and widely-peopled country to pass from our hands, either from a want of energy, or from a departure from those principles of trade and commerce whose foundations are built upon the rocks of integrity and honest dealing. Nothing marks the individuality of the Chinese more than that, wherever you meet him, whatever his surroundings may be, he is John Chinaman still; he never adopts the dress, manners, or customs of other nations, but he remains constant to the pigtail, the quaint dress, and the umbrella; and if established in communities, you will find him with his joss-house, food, theatre, and his refreshment-places just as if he were in China.

Our knowledge of the latest acquisition in the East, Burmah, has been largely increased during the past eighteen months. Important surveys in North-Eastern Burmah by Colonel Woodthorpe, R.E., and Mr. Ogle have opened up an area of about 1500 square miles; and the fact of practicable routes between Assam and Burmah *viâ* the Palka Pass is now established. Burmah, with its large and intelligent population (numbering about 4,000,000), with its valuable minerals and precious stones, with its tropical products, is well worthy of the attention of the merchant adventurer; and as our knowledge of the physiography of the country is rapidly increasing, a study of its applied geography is strongly recommended to the student.

In our own territory of British India large and important surveys have been carried on under the able direction of Colonel Thuillier. These surveys are conducted in what is called the protected region; but very interesting additions, especially to the merchant, are made in the outlying territories bordering upon our Indian Empire, where no white man could go, by the employment of intelligent natives especially trained for the purpose. The information obtained by these men may be very profitably studied.

These Central Asian problems are full of deep significance to those desirous of developing and retaining the supremacy of the trade of this Empire in those regions; and I am happy to state that papers full of interest on these subjects will be presented to you during this meeting.

Turning to the northern parts of Asia, I feel some diffidence in speaking before a Newcastle audience on the subject of Siberia, for through your own townsmen, and Captain Wiggins, you are well acquainted with these regions. The exertions made by Captain Wiggins and those connected with him in this enterprise should receive the highest commendation; and that they have been so far successful is a matter for rejoicing. At the same time, I cannot but think that Russia, continuing the policy she has so steadily pursued for some years past, against the commercial development of Great Britain, would not object to the employment of British capital in opening up trade in her outlying dominions; for that trade, once fairly established on good business lines, would be absorbed on behalf of her own manufacturers. I do not attach any blame to Russia in this matter, but I am of opinion that more profits are to be gained when trade follows the British flag, for then British enterprise and money reap more certain reward. If the energy, talent, and perseverance which have been exhibited by Captain Wiggins and his partners had been utilized in the development of some of our own territories rather than in the territory of another nation, I feel sure they would command that success to which they are so justly entitled.

From the consideration of Siberia and the Northern Seas it is not a far step to Greenland, whose icy regions and eternal snows have been crossed for the first time in our history. The hero of this exploit, Dr. Frithjof Nansen, is a native of Norway, and the exploration which he has so recently conducted to a successful issue was rightly alluded to by the President of the Royal Geographical Society, in his annual address, as the most conspicuous achievement of the year.

Though young in years, Dr. Nansen proved himself to be a leader of men, and the account of his adventures will be found to be full of interest. The results of his expedition deal rather with the world of science than with commerce, as his discovery proved Greenland to be nothing more or less than a continent whose interior is a huge region of ice and snow. It, however, presents a most interesting study to those desirous of advancing our knowledge of glaciers and the glacial period. Dr. Nansen's description of this immense mass of frozen snow, forcing its way coastwards from the higher plateaus of the interior, by sheer weight and pressure, grinding, crushing, resistless in its slow but ever-moving power, gives one a faint idea of how the hills and valleys of the world were formed when, in remote periods of time, they too were under glacial influences.

Crossing from Greenland to North America, we still find ourselves in regions where ice and snow hold undisputed sway for a considerable portion of the year. The Canadian Government, with commendable activity, keep pushing forward their surveys into what is known as the old Hudson Bay Territory. The Mackenzie River has been found to be a far larger body of water than formerly supposed. More accurate surveys as regards the size of some of the great lakes of those regions are being made, and our knowledge of the climate and the isothermal variations of British North America is each year increasing.

Petroleum has been discovered, and, as the geological surveys advance, other discoveries of an important nature may reasonably be anticipated. I have been told of the existence of a huge bed of porous sandstone, saturated with mineral oil, which burns like coal.

Moving southwards, we pass through the prairie-lands of the North-West of Canada, traversed by the Canadian Pacific Railway. These rich lands are being rapidly developed, and should form a happy home for some of our surplus population. Colonization is a subject full of geographical considerations, but it demands a special paper, and I have neither space nor time to introduce it into this address. At the western edge of these prairie-lands are the Rocky Mountains, in whose foot-hills are now being reared large herds of cattle and horses, as well as flocks of sheep. Some cattle from these fertile regions were shipped last year to the English market, and no doubt a regular trade will soon follow this experiment.

Crossing the Rockies in a westward direction, you come to the Selkirk Range, then to the Gold Mountains, and lastly to the Cascades, whose wooded rocky sides plunge into the Pacific. Constant explorations are being carried on through these mountain ranges, chiefly in researches after gold and other precious metals, and our knowledge of their physiography is rapidly increasing. The Rev. Mr. Spotswood Green, in an interesting paper concerning these regions, tells us something of the configuration of the Selkirk Range, which offers alike to the mineralogist, sportsman, and Alpine explorer a field of great interest.

Continuing southward, we pass through the fertile plains and valleys of California, whose large industries in grape and orange culture are being fostered and developed. And from California you enter into Mexico, whose wonderful mineral resources are receiving a new impetus by the construction of railways, 4700 miles of which are now open to traffic. These railways will not only facilitate the transport of the wealth of Mexico from the coast to the sea, but they tend also to promote law and order among its restless and lawless population. As law and good government are established, so will trade and commerce and the natural riches of the country be promoted and encouraged.

Crossing over to South America, we find considerable progress in commercial activity, chiefly due to the increased means of communication.

In the smaller Republics upwards of 1500 miles of railway have been recently constructed; while in the larger States, Brazil has 6000 miles; Peru, 3000 miles; Chili, 1630; and the Argentine Republic, 4700—making a grand total in South America of 17,000 miles of railways. This allusion to railways may not be considered as bearing on the science of geography;

but railways are very important factors as regards the commerce and trade of the world, and by the facilities they afford they largely increase the power of exploration.

The southern portion of South America has been described by those who have visited and explored its savannahs and prairie-lands as possessing one of the richest grazing-lands of the world, and its development is only a question of time. In its present condition it offers a very interesting field of research to the explorer.

Time does not permit us to dwell long on the islands of the Pacific. Recent events concerning Samoa are fresh in your memories; and while some of these islands have developed commercially, it is when they lie in the great ocean tracks of the world that their real importance is manifested. Take for example the island of St. Vincent, of the Cape Verde Group. It is nothing but a barren rock, without any produce whatever; all its water has to be brought from a neighbouring island; yet it pays a large revenue to the Portuguese Government simply from coal dues, for it has a good harbour and lies directly in the line between Great Britain and the principal ports of South America; it has therefore become a most important coaling-station.

From the isles of the Pacific it is but a step to Australia, with its six great colonies of Queensland, Victoria, New South Wales, South Australia, Western Australia, and Tasmania, to which may be added New Zealand. Virgin fields untrodden by the foot of the white man are still awaiting the explorer to yield up their treasures to the science of applied geography; and when the marvellous progress that has been made in a few short years by our Australian colonies is weighed and considered, and as its vast interior is opened by exploration, and its mineral resources are developed, who could venture to predict the future that lies before it?

There are now nearly 11,000 miles of railway in operation, and many more miles are in course of construction throughout these various colonies—a sure and certain indication of their energy, wealth, material prosperity, and progress. Geographically speaking, some are not without their troubles. Take Queensland for instance. Her territory runs north and south for nearly 1500 miles, and lies both in the temperate and tropic zones. The Governments who during past years have administered her affairs have experienced some difficulties whilst endeavouring to reconcile the conflicting interests which arise out of her geographical position.

Laws relating to labour and capital in a temperate zone are not always in conformity with the industries and requirements of a tropical temperature, in which the white man is obliged to employ labour suitable to the climate. Hence we find a numerous section of the inhabitants of the northern part of this colony agitating in favour of separation. Australia has large coal-measures, and abounds in precious metals as yet hardly developed.

Attached to Australia are the great and lesser islands forming the Australasian archipelago. The most important of these is New Guinea, and quite recently a successful exploration of its highest mountain range has been accomplished by the present administrator, Mr. Macgregor, who reached an elevation of about 14,000 feet. A very interesting paper was read before the Royal Geographical Society by Mr. Paul Thomson concerning the D'Entrecasteaux and Louisiade Groups, adjacent to New Guinea; and though many of these islands and their inhabitants are quite new to us, still the knowledge we gain from a study of their geographical position may be turned to practical uses by the merchant adventurer.

Last but not least in this record of geographical progress of the world is the vast continent of Africa.

As General Strachey, late President of the Royal Geographical Society, in his address of this year, remarks:—

"The reflection can hardly be avoided that, great as has been the advance of exploration in Africa during the last twenty or thirty years, the interest of geographers will, in the immediate future, be more and more centred in that continent. Excluding the polar regions, there is no considerable portion of the earth's surface, unless it is in Africa, the essential outlines of which have not been delineated."

These words are, I think, absolutely true. Whether we consider Africa in regard to the extraordinary explorations and developments since the commencement of the work of David Livingstone; or from the fact that vast areas of its tropical portion remain untouched as yet by exploration, and are therefore unknown; or from a contemplation of the teeming millions of its inhabitants, of which the larger portion have never seen a white man; or from the uncompleted work of the late General Gordon, and the re-establishment of the power of a civilized Government over the whole of the Nile basin; or from the slavery question, in which our nation has taken the most active and leading part; or from the spectacle of a white man, Emin Pasha, establishing a settled form of government in the heart of the continent, between the two great slave-dealing communities of the Bahr-el-Ghazal and that of the Upper Congo and Lake Tanganyika; or from the expedition sent to convey to him the succour he so much needs, under the leadership of Mr. H. M. Stanley; or from the intense interest recently exhibited by the nations of Europe in portioning out Africa between each other—an interest that has led on the west coast to the establishment of the Congo Free State, and the German protectorate in the Cameroons, France and Portugal adding largely to the possessions they already hold, and England contenting herself with strengthening her grip upon the Niger, and on the east coast by the formation of the British and German spheres of influence; or to the colonies which Great Britain possesses in the southern extremity of this great continent; or to the struggle which sooner or later must be fought out between Christianity and Mohammedanism as regards the native races of Central Africa, in which the River Congo will play an important part: I say when we consider all these and the many other problems of this continent, the vast interests they represent, and the varied influences they may yet exert on the future history of this earth, as well as the extraordinary part which Great Britain has been permitted to play in lifting the veil of mystery and doubt which up to our own times enveloped these regions, we are forced to acknowledge that the country in which the civilized world takes the most active and absorbing interest is Africa, and that the Dark Continent still maintains its supremacy.

As regards Africa two very remarkable journeys have recently been brought to a successful conclusion—that of Count Teleki, an Austrian, on the north, and that of Mr. Arnot in the regions south of the equator.

The former, entering Africa at Mombasa, at the head of a numerous and well-equipped caravan, passed through the Masai country by what is known as Thompson's route, and, pushing northwards, discovered Lake Rudolph, a large inland salt lake, and by following its shores he was enabled to trace with commendable accuracy its shape, size, and position. The existence of a large lake, called Samburu, in the direction of Count Teleki's journey, had for some time been spoken of by the Arabs who traded in that region, but nothing definite was known concerning it. Count Teleki also obtained much valuable information of the region between Mount Kenia and Lake Rudolph, its inhabitants, its rivers, and its products; and the details of his most interesting and successful journey have yet to be published.

Mr. Arnot, on the other hand, started in 1883 from Pietermaritzburg with a very slender equipment and hardly any following. His object was to prove the existence of healthy plateaus in the interior of Africa, where white men could live and prosecute the work of missionary civilization without being exposed to the malarial influences which exist in so many parts of Central Africa.

Taking a northerly course, he reaches the Zambesi, whose waters he follows as far as Lealui. From this point his route trends to the west as far as Robongo, the capital of the Bihé country. From Robongo he continues his march to Bailundu, and from thence he reaches Benguela, on the west coast. Thus he crossed Africa in the same direction as Livingstone's first journey, though somewhat to the south of Livingstone's route. While at Bailundu he meets some messengers from Msidi, the chief of the Garangenze country, who beseech him to visit their king; and having replenished his stores, he retraces his steps to the interior.

From January 1885 to February 1886 he perseveres in his attempt to reach the capital of Msidi's country, and his efforts are at length crowned with success. After a sojourn among these people for two years, during which time he thoroughly succeeded in obtaining their confidence and that of their ruler Msidi, he returned to Europe in the latter part of last year, but not before he had established two other white missionaries at Mukururu to continue the work he had begun.

He also made several small expeditions during his residence at Mukururu, the most interesting of which was to the cave-dwellers of Urua, mentioned by Livingstone. This kingdom of Garangenze is situated to the east of Lake Moero; and Mr.

Arnot has recently published a book of his travels, giving a very clear and interesting account of these people, their manners, and their customs. Of all Livingstone's followers, Mr. Arnot very closely resembles the great leader in the patient earnestness, the quiet energy, and the scanty resources with which he prosecuted his remarkable journeys.

He has quite recently returned to the west coast of Africa with the intention of rejoining his friends at Garangenze.

The events which attended the expedition under Mr. H. M. Stanley to succour and relieve Emin Pasha are so well known to you all that I shall only attempt a brief recapitulation here.

We have learned from his own pen how, after much suffering and great hardships, he eventually overcame all the difficulties and obstacles which had to be encountered while conducting his caravan from the head waters of the Congo to the lake Albert Nyanza; that on reaching that lake he met Emin Pasha.

The value of Mr. Stanley's journey and the remarkable energy and courage he displayed, his high scientific attainments, and the information that will result from his labours, are, from a geographical point of view, of the highest interest. The desiccation of the lake Albert Nyanza, and its influences on the rise and fall of the Nile, are not the least remarkable of these problems. For my own part, I am of opinion that this rise and fall is mainly caused by the rapid growth of tropical water-plants. During the dry season this vegetation increases enormously, and at the first rains large masses of aquatic growth are loosened by the rising of the waters. These masses, in the form of floating islands, pass downwards on the bosom of the flowing waters, and on reaching a wide and shallow part of the river, such as we find at the Bahr-el Ghazal, they gradually but quickly collect till they form a dam of sufficient density to obstruct the progress of the river; and the water thus arrested finds a temporary lodgment in the lake Albert Nyanza, causing it to overflow its normal boundaries. At length the vegetable dam can no longer withstand the weight and pressure of the water bearing upon it; a portion gives way; a channel is opened; and the river, hurrying on to the sea, overflows the banks of the Lower Nile and drains the lake to a lower level. This is what happens to the Albert Nyanza, which is nothing more than a huge backwater of the Upper Nile basin, and it accounts for the lake being seen at two different levels by those two distinguished explorers Mr. H. M. Stanley and Sir Samuel Baker, and hence the difference of opinion as to its true extent and size that has arisen between them. We know that this phenomenon takes place on Lake Tanganyika, as Stanley found a marked difference in its level on the two occasions he rested upon its shores. He also followed the Lukuga River from the Tanganyika Lake to its junction with the Congo; and there is no doubt that a vegetable dam, such as I have described, forms at the point of departure of this river from the lake, and prevents its regular flow till the weight and pressure behind it sweeps all away. During the second year that I was on the Congo we had an unusually heavy flood at the time of the first rains. The river rose several feet in one night, and some months afterwards news came from the Upper Congo that the waters of the big lake had broken through, and this no doubt had reference to the Lukuga River and Lake Tanganyika.

Now, as regards the countries through which we have been passing, there are certain points of great interest connected with the science of applied geography, to which I desire to draw your special attention.

The first of these points is the study of the great railway systems of the world, and the application of railways to the development of new countries. Take our Indian possessions for example. What a change has been wrought, not only as regards the commerce of the country, but also with reference to the social condition of its inhabitants and their manners and customs! The introduction of Indian wheat, by means of these railways, into the markets of Europe has caused a revolution in the trade in that commodity. We find this especially in America, where it has upset the calculations of those gigantic combinations or rings which sought to obtain a monopoly in the supply of this universal article of food. Thus the construction of railways in the East exercises commanding influences over the markets of the West.

Consider also the traffic from China and Japan to America, with its 60,000,000 people, by means of the great Atlantic and Pacific railways, in tea and raw materials. Now, although railways cannot compete with direct traffic by sea, when the necessity for more rapid conveyance of certain goods arises, we find that a combination of sea and land transport is often adopted in preference to the longer route by sea alone.

The development of any country, no matter what its geographical position may be, is enormously increased by the construction of railways. Take the Congo Free State as an instance (which is undoubtedly the finest property in Central Africa). So long as the Upper Congo region, with its miles—measured by thousands—of navigable tributaries, was separated from the Lower Congo by the rapids extending from Stanley Pool to Matadi, this magnificent territory was practically shut to trade and commerce. Every piece of goods in the interior had to be carried on men's heads for more than 200 miles, and all ivory and other products were brought to the coast in the same way. Roughly speaking, such transport costs about £40 per ton.

The Congo Free State has wisely determined to build a railway, of some 250 miles in length, to cross this cataract region; and the moment it is completed the future of that country is assured.

H.M. the King of the Belgians has kindly given permission for a Belgian officer of distinction, Captain Thys, to read a paper at this meeting on this railway, which will afford a more detailed account of this wise and patriotic undertaking.

I have mentioned railways as the first point of interest because they are creations of our own time, and have therefore a special interest of their own; but the most important factor in the early history of the science of applied geography, and to which the establishment of our great colonial empire is mainly due, is the record of the merchant adventurers.

Their voyages and exploits, extending to every part of the globe, began at the end of the fourteenth century, in the reign of Henry VIII., when the Cabots (Venetians) sailed from England to Newfoundland, and afterwards to Florida. This expedition and those which followed it were fitted out at the expense of corporations of merchants, with the object of extending the commerce of the country by a search after trade in new and foreign lands. They were placed under the command of some well-known leader, and the results obtained were extraordinary.

In 1530 the merchant adventurers of England attempted the North-West Passage, as it is called, to China, and between 1550 and 1578, Sir H. Willoughby, Frobisher, and Sir H. Gibbon all made remarkable voyages.

Between 1585 and 1615, Davis, Hudson, and Baffin were sent by merchant companies to the polar seas, and their discoveries are handed down by the straits and bays which they discovered, and which bear their names.

In 1580 Drake took the first English vessels into the Pacific Ocean. Drake was not only a bold and successful navigator, but he was also a commander of men, in which he showed rare tact and ability.

In 1588 the merchants of Exeter established a trade with the West African coast, and the Senegal Company was formed.

In 1553 the first effort to reach India was made *viâ* the Cape of Good Hope. It was not, however, till the year 1660 that any progress was made in the East. In that year the East India Company was formed, and it is to the establishment of this Company that we owe our great Indian Empire. The year 1669 saw the formation of the Hudson Bay Company—a Company which exists at the present day. And so the record goes on down to our own times. Not the least amongst the trading corporations of Great Britain were the merchant adventurers of this city in which we are now assembled; and they, too, contributed in no small degree, not only in the past but in the present, to the extension of our geographical knowledge and its application as a science. No doubt the spirit and energy of our Scandinavian forefathers has been fostered and encouraged until it has now found its development in the enterprise and prosperity of this great mercantile centre of the north of England. And the old churches of Jarrow and Monkwearmouth bear further testimomy to the fact that, as commerce drew together communities which became centres of maritime energy and progress, religion was not forgotten, and the seed of knowledge and truth thus sown in the early history of the past has spread itself throughout the length and breadth of the great colonial empire of Greater Britain.

Following on the discoveries of the sixteenth and seventeenth centuries, and the marvellous results to which they have given birth, the story of our own times, from a geographical point of view, is quite as wonderful. As I remarked at the beginning of this paper, the discovery of steam as a motive power has brought the world into an extraordinary condition of contactiveness, and quite recently several new companies have been formed in the same spirit and on the same lines as those followed by the old merchant adventurers. These later creations are being started under more favourable conditions than their predecessors, for they have all the advantages which modern science and modern appliances can afford. The English Government have wisely encouraged and promoted the formation of these trading corporations. In countries where climate and circumstances of environment are not favourable to colonization by white men, our colonial system of government progresses somewhat slowly. It has not the elasticity, nor the adaptability, to provide for the many contingencies which must naturally arise when a few white men maintain the position of rulers over large areas, peopled by savage and uncivilized races.

In the Island of Borneo there is the North Borneo Company trading, governing, and civilizing a large portion of territory with marked success.

On the west coast of Africa, the Royal Niger Company is developing the great natural resources of that magnificent river, and its tributary the Binué.

On the east coast there is the Imperial British East African Company, operating in what is known as the British sphere of influence north of Zanzibar. Though not a twelvemonth has passed since they commenced their work, their initiatory proceedings have been remarkably successful, and there is every prospect of an early and rapid development of the territory committed to their charge. In the south-eastern portion of Central Africa, the African Lakes Company have fairly established themselves; and a new company is now being formed to open up and civilize a further portion of that section of the African continent.

The establishment of these great trading and governing centres is likely to exercise most important influences. They are, as I have before pointed out, from their organization and objects, better adapted at the outset to compete with and overcome the obstacles which present themselves to established forms of bureaucratic government; at the same time the Government of this country can interfere in cases of necessity, by the grants that have been made to them of Royal Charters, under which they carry on their operations.

A wise control and judicious administration combined with the introduction of commerce and civilization will, at no distant date, open these territories to the markets of the world, to the missionary, and to the scientific explorer. The commercial element of geography also enters very largely into their promotion and prosperity because of the fields they open to our home manufactures. It is important here to observe that, if these territories had passed into the hands of other nationalities, but a very limited quantity of British goods would ever have entered into them, and their value, as a market for the industries of the nation, would have been lost.

The establishment of a Geographical Society in this city is of real importance. Its objects should be the collection of information, and the study of applied geography in all its varied branches and aspects. It should aim to furnish complete information concerning the geography of all parts of the globe. In Chambers of Commerce our large trade centres have, no doubt, means of guiding and controlling some of our most important mercantile operations, but they afford no opportunities to the student, they are not teaching bodies; and there are instances where considerable risks have been incurred and heavy losses sustained in some of their ventures, simply from a want of knowledge of geographical data.

I should like to see a Geographical Society in every large city of this Empire, conducted on the lines I have briefly suggested, because the study of, and interest in, the commercial geography of this great Empire and the world is too much neglected amongst us. Past prosperity, and a tendency to run in the same groove, narrow our commercial horizon. Slowly, but surely, other nations, competing with us in many parts of the world, are doing so successfully because of the study they make of commercial geography.

It is for this reason I have in my address dwelt strongly upon the question and study of geography as an applied science, and it is for a greater reason I urge its importance, viz. that we may hand down to our children unimpaired the heritage bequeathed us by our forefathers; a heritage gained by courage, energy, perseverance, and patriotism—qualities which, under God's blessing, have made this nation the head of the commerce of the world.

SECTION F.

ECONOMIC SCIENCE AND STATISTICS.

OPENING ADDRESS BY PROF. F. Y. EDGEWORTH, M.A., F.S.S., PRESIDENT OF THE SECTION.

Points at which mathematical reasoning is applicable to political economy—

A.—Perfect competition—
1. Simplest type of market.
2. Complex system of markets; simplified by certain abstractions.
3. The more concrete problem of an exchange and distribution.

B.—Monopoly—
1. Transactions between a single monopolist and a competing public.
2. Transactions between two monopolists or combinations.

The use of these applications of mathematics to political economy illustrated by comparison with—
1. Applied mathematics generally.
2. The mathematical theory of statistics.

Conclusion.

AT the meeting of the British Association which was held at Cambridge about a quarter of a century ago, Jevons submitted to this Section a "general mathematical theory of political economy," which, as he himself records, was "received without a word of interest or belief." I propose to consider the justice of the unfavourable verdict which our predecessors appear to have passed on the mathematical method introduced by Jevons.

There is some difficulty in discussing so abstruse a subject in this place. It is as if one should discourse on the advantages of classical education on an occasion on which it might seem pedantic to cite the learned languages. I shall evade this difficulty by addressing to students some appended notes,[1] which, like the boy of proverb, are to be seen, not heard.

The cardinal article of Jevons's theory is that the value in exchange of a commodity measures, or corresponds to, the utility of the least useful portion of that commodity. What a person pays per month or year for a sack or ton of coal is not what he would be willing to give for the same rather than be without fuel altogether. Rather the price is proportioned to the advantage which the consumer expects from the portion which he could best dispense with—to the "final utility," in Jevons's happy phrase.

I shall not be expected here to dwell on a subject which has been elucidated in treatises of world-wide reputation, such as those of Profs. Marshall, Sidgwick, Walker, and I would add Prof. Nicholson's article on "Value" in the "Encyclopædia Britannica." Those writers seem to present what I may call the economical kernel of Jevons's theory divested of the mathematical shell in which it was originally inclosed; whereas my object is to consider the use of that shell—whether it is to be regarded as a protection or an encumbrance.

I may begin by removing an objection which the mere statement of the question raises. The idea of reducing human actions to mathematical rule may present itself to common-sense as absurd. One is reminded of Swift's "Laputa," where the beef was cut into rhomboids and the pudding into a cycloid, and the tailor constructed a very ill-fitting suit of clothes by means of rule and compasses. It should be understood, however, that the new method of economical reasoning does not claim more precision than what has long been conceded to another department of science applied to human affairs—namely, statistics. It is now a commonplace that actions such as suicide or marriage, springing from the most capricious motives, and in respect of which the conduct of individuals most defies prediction, may yet, when taken in the aggregate, be regarded as constant and uni-

[1] The appended notes are referred to by letters of the alphabet, thus: (a).

form. The advantage of what has been called the law of large numbers may equally be enjoyed by a theory which deals with markets and combinations.

But, indeed, even the limited degree of arithmetical precision which is proper to statistical generalizations need not be claimed by our mathematical method rightly understood. It is concerned with quantity, indeed, but not necessarily with number. It is not so much a political arithmetic as a sort of economical algebra, in which the problem is not to find x and y in terms of given quantities, but rather to discover loose quantitative relations of the form: x is greater or less than y, and increases or decreases with the increase of z.

Such is the character of what may be called perhaps the leading proposition in this calculus—namely, the mathematical theory of supply and demand. The use of a curve introduced by Cournot to represent the amount of a commodity offered, or demanded, at any particular price, supplemented by Jevons's theory of final utility (*a*), does not indeed determine what price will rule in any market. But it assists us in conjecturing the direction and general character of the effect which changes in the condition or requirements of the parties will produce. For example, in the case of international trade the various effects of a tax or other impediment, which most students find it so difficult to trace in Mill's laborious chapters, are visible almost at a glance by the aid of the mathematical instrument (*b*). It takes Prof. Sidgwick a good many words to convey by way of a particular instance that it is possible for a nation by a judiciously regulated tariff to benefit itself at the expense of the foreigner. The truth in its generality is more clearly contemplated by the aid of diagrams such as those employed by the eminent mathematical economists Messrs. Auspitz and Lieben (*c*).

There seems to be a natural affinity between the phenomena of supply and demand and some of the fundamental conceptions of mathematics, such as the relation between function and variable,[1] between the ordinate of a curve and the corresponding abscissa,[2] and the first principle of the differential calculus; especially in its application to the determination of *maxima* and *minima*. The principle of equilibrium is almost as dominant in what Jevons called the mechanics of utility as in natural philosophy itself. In so many instances does mathematical science supply to political economy what Whewell would have called "appropriate and clear" conceptions. Their use might, perhaps, be illustrated by comparing—however fancifully, and *si parva licet componere magnis*—the advance in economics which Jevons initiated or continued to the advance in mathematics which the new and sublime method invented by Sir William Hamilton appears to have effected. Algebra and geometry are to ordinary language in political economy somewhat as quaternions are to ordinary algebraic geometry in mathematical physics, if we accept the view of the latter relation which has been given by a very competent judge, Clerk Maxwell. "I am convinced," he says, "that the introduction of the ideas as distinguished from the operations and methods of quaternions will be of great use in the study of all parts of our subject, and especially . . . . where we have to deal with a number of physical quantities, the relations of which to each other can be expressed far more simply by a few expressions of Hamilton's than by the ordinary equations."[3] This is the spirit in which the economist should employ mathematics—"the ideas as distinguished from the operations and methods."

In considering the above-given, and indeed any concrete instances, it is hardly possible to keep to what may be called the simplest type of supply and demand, the ideal market in which we contemplate only two groups of competitors and only two articles of exchange; say, gold for corn, or any other *quid pro quo*. In general, and especially when considering what rates of exchange tend to rule in an average of transactions, it is proper to take into account that the dealings in one market will affect those in another. If the *entrepreneur* has less to pay for machinery, *cæteris paribus*, he will be able to offer more on the labour market. Thus we obtain the idea of a system of markets mutually dependent. In a general view of this correlation it is not necessary to distinguish whether the state of one part is connected as cause or effect with the other parts of the system. As Prof. Marshall[1] says:—"Just as the motion of every body in the solar system affects and is affected by the motion of every other, so it is with the elements of the problem of political economy" (*e*).

This conception of mutually dependent positions is one in which minds disciplined in mathematical physics seem peculiarly apt to acquiesce. In other quarters there may be observed a restless anxiety to determine which of the variables in a system of markets is to be regarded as determining or regulating the others. In one of the principal economic journals there has lately been a pretty stiff controversy on the question which of the parties in the distribution of the national produce may be regarded as "residual claimants upon the product of industry" (*Quarterly Journal of Economics*, 1887, p. 287; 1888, p. 9); whether it is the working class which occupies this preferential position, or if the "real keystone of the arch" is interest. Such questions certainly admit of a meaning, and probably of an answer. But they will probably appear of secondary importance to those who accept, as the first approximation to a correct view of the subject, the principle of mutual dependence—what may be called the Copernican theory of distribution, in which one variable is not more determined by another than the other is by that one (*f*).

Among the factors of this economic equilibrium I have not as yet explicitly included cost of production. Rather, the system of markets which so far I have had in view is that which would arise if the articles of exchange were periodically rained down like manna upon the several proprietors, and each individual sought to maximize his advantage according to the law of final utility. But now we must observe that self-interest does not operate in this fashion. We must take account of efforts and sacrifices.

Here, again, the language of symbol and diagram is better suited than the popular terminology to express the general idea that all things are in flux, and that the fluxions are interdependent. In Prof. Marshall's words, "As a rule, the cost of production of a thing is not fixed; the amount produced and its normal value are to be regarded as determined simultaneously under the action of economic laws. It, then, is incorrect to say, as Ricardo did, that cost of production alone determines value; but it is no less incorrect to make utility alone, as others have done, the basis of value" ("Economics of Industry," p. 148). Among those who may have gone astray in the latter sense, who, in their recoil from Scylla, are at least sailing dangerously near Charybdis, may be placed the important Austrian school who have rediscovered and restated the theory of final utility without the aid of mathematical expression. To amplify a figure suggested by one of them,[2] let us figure the hard conditions of industrial life by the austerity of a schoolmaster, who, in order to cultivate patience and fortitude in his scholars, should distribute among them certain rewards—it might be toys and sweets—in return for certain amounts of fatigue and pain endured. Thus, the cost of procuring a marble might be writing out twenty lines; the cost of a top, standing half an hour in the stocks. Supposing exchange to be set up among the members of the youthful population, free competition being assumed, there would theoretically arise an equilibrium of trade in which the value of each article would correspond to its final utility. That is, if a top exchanged for ten marbles, it might be expected that each boy would prize the last top about as highly as the last decade of marbles which he thought fit to purchase. So far, final utility may be regarded as the regulating principle.

But it is equally true that the final *dis*-utilities of the exchanged articles will be equal. If a top is worth ten marbles, we are entitled to expect such an adjustment of trade that each and every boy would as soon stand in the stocks half an hour as

[1] The treating as constant what is variable—e.g. *supply*, *margin*, *wages fund*, is the source of most of the fallacies in political economy.

[2] For instance, the two meanings of increased demand—which Mr. Sidgwick has contrasted as the *rise* and the extension of demand—are most easily and with least liability to logomachy distinguished as the variation of an ordinate (1) due to the displacement of the curve, the abscissa not varying, or (2) corresponding to an increment of the abscissa, the curve being undisturbed.

[3] Clerk Maxwell, "Electricity and Magnetism." Art. He says in the context: "As the methods of Descartes are still the most familiar to students of science, and as they are really the most useful for purposes of calculation, we shall express all our results in the Cartesian form." Compare Prof. Marshall's dictum with respect to the use of the vulgar tongue in "Economic Reasonings," cited below, p. 9.

[1] In a remarkable review of Jevons's theory in the *Academy* of April 1, 1872.

[2] Cf. Prof. Böhm Bawerk: "Es kann ein Erzieher einem Knaben, um ihn gegen Weheleidigkeit abzuhärten, für die tapfere, freiwillige Erduldung von Schmerzen ein sehnlich begehrtes Spielzeug in Aussicht stellen. So untergeordnet das Vorkommen solcher Fälle auch sein mag, so wichtig ist es für die Theorie festzustellen, dass Arbeit und Arbeitsplage doch nicht der einzige Umstand ist, auf den sich . . . die Wertschätzung gründen kann."—*Konrad's Jahrbuch*, 1886, p. 43.

write out two hundred lines—the cost of ten marbles at twenty lines per marble.

To be sure, final utility may be conceived as operating by itself without reference to cost of production, as we tacitly assumed in our first paragraphs. Whereas the converse conception of a traffic in discommodities[1] has less place in real life.

But it is not worth while weighing the two principles against each other, *in vacuo*, so to speak, and abstracting the real circumstances by which each is differently modified. As these are introduced, the balance will oscillate now in favour of one side, now of the other; perhaps leaving it ultimately uncertain whether cost of production or final utility is the more helpful in the explanation of economic phenomena.

For instance, in our allegory let us introduce the supposition that there is only one variety of cost—say, the common labour of writing out verses. If, now, the authorities fix twenty lines as the cost of a marble, and 200 as the cost of a top, it is predictable that a top will be worth ten marbles. It is equally true indeed, now as before, that the final utility of a top will be equal to the final utility of ten marbles. But the latter proposition, though equally true, is not equally useful. For it does not afford the simple and exact method of prediction which is obtained by the Ricardian view upon the supposition made. But then the supposition that there is only one variety of sacrifice is not always appropriate. And even if that were appropriate, it might not be helpful when we introduce the condition that the cost of procuring each article is not fixed definitely, but varies increasingly or decreasingly with the amount procured. Thus, the cost of the first marble given out might be twenty lines; of the next marble, twenty-one lines; with an equally varying scale for tops. Upon this supposition the two propositions that value corresponds to final utility and also final disutility might be equally true, but equally useless for the purpose of prediction.

Again, it may be that a man is freer to vary the extent of his expenditure than the duration of his work (*g*). The final disutility experienced by the Secretary of this Association during its meetings must be fearful. For it is not open to him to terminate at pleasure his day's work, as if he were employed by the piece. He would not, however, have accepted the office unless the advantages, less by all the trouble, were at least as great as in any other position open to him. Now this equation of the net advantages in different occupations is—co-ordinately and (in a mathematical sense) *simultaneously* with the equation of final utility for different kinds of expenditure—a condition of normal economic equilibrium (*h*). Yet again, the free play of this tendency is impeded by the existence of "non-competing groups."

I cannot be expected here to enumerate all the conditions of economic equilibrium. For a complete exposition of the complexities at which I have thought it necessary to glance, I must refer to the second book of Prof. Sidgwick's "Political Economy." It will be evident to his readers[2] that what may be called the general economic problem of several trading bodies distributing and exchanging *inter se* under the influence of self-interest and in a *régime* of competition is much more hopelessly difficult than the as yet imperfectly solved dynamical problem of several material bodies acting on each other *in vacuo*. When Gossen, the predecessor of Jevons as an exponent of the law of final utility, compares that principle to the law of gravitation, and the character of our science to that of astronomy, he betrays a too parental partiality. A truer, though still too flattering, comparison would be afforded by some very immature and imperfect specimens of physics—say the theory of fluid motion applied to the problems of house ventilation.

There is a certain resemblance between the uniformity of pressure to which the jostling particles of a gas tend and the unity of price which is apt to result from the play of competition. As the architect is guided by studying the laws according to which air flows, so it will help the builder of economic theory to have mastered the principle of movement towards equilibrium. But even in the material constructions practice is apt to lag far behind theory, as every reader in the British Museum knows. Much less are we able to predict what currents will flow between the different compartments of the industrial system. We know so imperfectly the coefficient of fluid friction, and the other conditions of the general problem: what compartments may be regarded as completely isolated and hermetically sealed, which partitions are porous and permeable.

Moreover, there is one operation of competition, which it does not seem easy or helpful to represent by physical analogies—the transference from one occupation to another, the equation of net advantages or total utilities in different employments; industrial as distinguished by Cairnes from commercial competition. The latter operation appears to me to admit much better of mathematical expression than the former, which is not so well represented by the equilibrium of a physical system.[1] Accordingly, the equation of net advantages has been judiciously omitted by Jevons in his formulation of the cost of production. And the Helvetian Jevons, as we may call Prof. Walras, appears to have altogether made abstraction of the cost of production considered as importing sacrifice and effort.

Prof. Walras, illustrating the operation of a simple market, supposes each dealer, before going to market, to write down his scale of requirements—how much he would be willing to buy or to sell at each price. From these data it would be easy to calculate beforehand the rate of exchange which would prevail in the market formed by those individuals. But, when we advance from the simplest type of market to the complexities introduced by division of labour, it is seen to be no longer a straightforward problem in algebra or geometry, given the natures of all the parties, to find the terms to which they will come. Here, even if we imagine ourselves in possession of numerical data for the motives acting on each individual, we could hardly conceive it possible to deduce *a priori* the position of equilibrium towards which a system so complicated tends.

Accordingly, it may be doubted whether the direct use of mathematical formulæ extends into the region of concrete phenomena much below the height of abstraction to which Jevons has confined himself. However, the formulation of more complicated problems has still a negative use, as teaching the Socratic lesson that no exact science is attainable. As Dupuit, one of the greatest of Jevons's mathematical predecessors, points out, "Quand on ne peut savoir une chose, c'est déjà beaucoup que de savoir qu'on ne sait rien" (*Annales des Ponts et Chaussées*, 1844, p. 372). If, he says, the early theorists, instead of formulating the balance of trade, had confined themselves to declaring the question above their powers, they would probably have done a greater service than the successors who refuted them. So Cournot, referring to his own mathematical treatment of economics, "Aussi nos modestes prétensions étaient-elles non d'accroître de beaucoup la domaine de la science proprement dite, mais plutôt de montrer (ce qui a bien aussi son utilité) tout ce que nous manque pour donner la solution vraiment scientifique de questions que la polémique quotidienne tranche hardiment" ("Revue Sommaire"). Similarly Jevons says ("Theory of Political Economy," p. 157, second edition), "One advantage of the theory of economics, carefully studied, will be to make us very careful in our conclusions when the matter is not of the simplest possible nature."

In the vineyard of science, to perform the part of a pruning-hook is an honourable function; and a very necessary one in this age of luxuriant speculation, when novel theories teem in so

[1] Suppose our allegorical schoolmaster should discontinue the system of rewards, and prefer to cultivate diligence by requiring each boy from time to time to bring up a certain number of lines, written out—whether by himself or another would not be scrutinized—or to be responsible for the cleaning of a window, after the manner of Mr. Squeers's practical method. In the traffic of discommodities which would be set up on this supposition, the (negative) value of each article of exchange would be measured solely by its disutility. However, it must be admitted, I think, that this latter hypothesis is rather more absurd than the former abstraction—with reference to real life at least; for, as it happens, the traffic in impositions more nearly resembles what is said to occur in actual schools.

[2] There occurs to me only one point at which the use of mathematical illustrations more complicated than those which I have referred to in my first two headings would conduce to the apprehension of Mr. Sidgwick's theorems. I allude to his repeated statement that, not only in international trade, as Mill pointed out, but also in trade in general, there may be several rates of exchange at which the supply just takes off the demand. This statement, taken without reservation, goes the length of destroying the prestige which is now attached to competition. Prof. Marshall, in an important passage, recommends arbitrators and combinations to imitate the method of a celebrated engineer, who, in order to make a breakwater, first ascertained the slope at which a bank of stones would naturally be arranged under the action of the waves, and then let down stones so as to form such a slope ("Economics of Industry," p. 215). Now, if gravitation acted sometimes vertically and sometimes at an angle of 45°, if the forces of competition tended to two distinct positions of equilibrium, the construction of the economic breakwater would become arbitrary. It is important, therefore, to show the limits of Prof. Sidgwick's theory. See the appended note (*j*).

[1] Commercial competition might be likened to a system of lakes flowing into each other; industrial competition to a system of vessels so communicating by means of valves, that when the level of one exceeded that of another to a certain extent, then *per saltum* a considerable portion of the contents of that one (a finite difference as compared with the differentials of the open system) is discharged into the other.

many new economic journals. I give in the appended notes an example of this corrective process applied to a theory of great worth and authority, and concerning the most vital interests, such as the relations of employer and employed, and the Socialist attack on capital (*i*). In directing this weapon of criticism against Prof. Walker, I act upon the Miltonic rule for selecting an adversary—

> "Best with the best, more glory will be won,
> Or less be lost."

In the preceding remarks I have had in view, as presumably most favourable to computation, the case of bargains in which there is competition on both sides. It is now to be added that the mathematical method is nearly as applicable to a *régime* of monopoly. Here Cournot, rather than Jevons, is our guide. Cournot's masterly analysis of the dealings between a monopolist seller and a number of buyers competing against each other has been copied out of mathematics into the vulgar tongue by many well-known writers, and need not here be repeated (*k*).

It is in this department, perhaps, that we can best answer Cairnes's challenge to Jevons to produce any proposition discovered by the mathematical method which is not discoverable by ordinary reasoning. Not, indeed, that the economist is bound to answer that challenge; any more than, in order to prove the advantages of international trade, he is concerned to deny that claret may be produced in Scotland.

The following proposition is a particular case of a more general theorem given by Cournot. Let there be a railway and a line of steamers, each forming part of a certain through journey, and separately useless; the fares will be lower when both means of transport belong to a single company than where there is less monopoly, the two services being in the hands of two companies, each seeking its own gain independently of the other.

The *rationale* of this somewhat paradoxical proposition is not easily discerned without the aid of symbols. Cournot, in a popular redaction ("Revue Sommaire") of the theories which he first conceived in a mathematical form, suggests, as a generally intelligible explanation, that it is better to be at the mercy of a single master than of several petty tyrants. But this seems to be a commonplace of the sort which, in the absence of rigid reasoning, has so often deceived the amateur economist. Might it not be applied to the case of monopoly in general?

It would be hard to say how much this remarkable proposition may add to the arguments in favour of the Government monopolizing railways. Nor would I undertake to estimate the practical significance of Cournot's numerous mathematical theorems on the taxation of monopolists. We might perhaps compare the function of the sovereign science with respect to the theory of monopolies to the duty of Government as to their management—to exercise a general supervision without attempting to control details.

We have in the last few paragraphs been supposing monopoly on one side of the market, on the other side a public competing with each other. Let us now consider the bargain between two monopolists, whether individuals, or rather corporate trading-bodies, combinations in the most general sense of the term. The mathematical analysis of this case brings very clearly into view the important property, which is not very prominent in writings of the pre-Jevonian era, that the bargain between two self-interested co-contractors is not determinate in the same sense as in a *régime* of perfect competition.

No doubt, if we take a very simple case—such as that imagined by De Quincey, of the bargain between the owner of a musical-box and a colonist already on his way to a distant region where no luxuries can be purchased—it is easy to see that the bargain may settle down at any point between certain limits. But where both the amount of commodity to be sold and money to be paid are variable, as in the momentous case of a bargain between a combination of employers on the one hand and *employés* on the other, it is a less familiar truth that the terms of the contract are in general to some extent indeterminate. For instance, the bargain may be either all in the interest of the one party, say long hours and small pay, or, on the other hand, high wages with much leisure.

The significance of this proposition has been missed by many of those who have treated the subject without the aid of the appropriate apparatus. Some fail to see that there is any peculiarity in the bargain between isolated units. Another discerns the indeterminateness of the bargain only in the special case in which the article exchanged is a large indivisible object, like a house. Another limits the difficulty to the case of a single negotiation as distinguished from a contract which, as in the actual labour market, may be modified from time to time. Another tells us that in such a bargain the most anxious party gains least.

All these phrases seem to obscure the cardinal distinction that perfect competition tends to a determinate settlement, whereas in a *régime* of combination a principle of adjustment is still to seek. What is that principle?

At a former meeting of the British Association, on the occasion of a discussion on sliding scales, I stated the difficulty which there might be, in the absence of competition, in defining fair wages and reasonable terms, and I asked the eminent Professor who introduced the subject in what direction one should look for a solution of this difficulty. His reply imported, as I understood, that no other general rule can be given but this: to obtain a full knowledge of, and bring a candid judgment to bear on, all the circumstances relevant to each case. To which I would add that one circumstance relevant to this whole class of cases is just the fact that there is in the abstract such a marked difference between combination and competition.

Possibly the dry light of abstract science may enable us to see a little further into this difficulty. Analysis strongly suggests that the right solution is what may be called the utilitarian arrangement, that which is productive of the greatest sum total of advantage for all concerned. The utilitarian determination is clearly discerned to be by no means necessarily coincident with the settlement towards which competition tends. For instance, the *vrai prix*, in Condillac's sense, as determined by the play of supply and demand in the labour market, might be such that the *entrepreneur* class should take the lion's share, leaving the labourer a bare and painful subsistence; but there is no ground to believe that this is the best possible arrangement. From an abstract point of view it is by no means evident that a free labour market "is the only way to equity, that any interference with it must involve injustice" (Danson). Nor need it appear "a great fundamental principle—as inevitable in its action as gravitation—that a fair day's wages for a fair day's labour is determined by the proportion which the supply in the market bears to the demand" (Rupert Kettle on "Arbitration"). It may be true indeed, in a practical sense, that perfect competition is "not less harmonious and beneficent in its operation than gravity" (Walker, "Political Economy"); but theoretically it is tenable that there is an adjustment of contracts more beneficent than that which the mechanical play of competition tends to establish (*l*).

To introduce these philosophical conceptions of utilitarianism will doubtless seem irrelevant to those who are immersed in the details of business. But the practical man should be reminded that in other spheres of action, politics and morals, the principle of utility, however badly received at first, has exercised a great influence—though doubtless not so great as was anticipated by some theorists, and requiring to be largely tempered with common-sense.

Such, I think, are the principal points at which mathematical reasoning is capable of being applied to political economy. In estimating the use of this method it is natural to take as our standard the helpfulness of mathematics in other departments of science.

As compared with mathematical physics, the mathematical theory of political economy shows many deficiencies. First, there is the want of numerical data, which has been already noticed. It is true that there is a faint hope of obtaining what Jevons too confidently expected—statistical data for the relations between supply and price. It is true also that in the higher mathematics conclusions which are quantitative without being numerical are more frequent than is usually supposed. Some political economy is as exact as some mathematical physics. The fields cultivated by Section A and Section F may overlap, but it must be admitted that the best part of our domain corresponds to what is the worst part of theirs. If you inquire as to the products of our inferior soils, we must confess, if we do not wish to conceal the nakedness of the land, that over a large portion of our territory no crop is produced. We are employed only in rooting out the tares which an enemy has planted. Much of our reasoning is directed to the refutation of fallacies, and a great part of our science only raises us to the zero point of nescience from the negative position of error. "*Sapientia prima stultitiâ caruisse.*" In this introductory portion of political economy we have seen that the mathematical method is likely to be serviceable (see above, p. 498).

It is not to be supposed, however, that the work of our Section is wholly destructive; that like the islanders of whom it was said that they earned a precarious livelihood by washing one another's clothes, so we are occupied only in mangling each other's theories. Like imprudent sectaries, by our mutual recriminations we have obscured the virtues common to our profession. What Jevons said of Cairnes, that his own opinions were much more valuable than his objections against other people's opinions, is true of Jevons himself and other controversial economists. Now, this possibility of mutual misunderstanding by persons who are both in the right is connected with a circumstance which it is not irrelevant here to notice. It is that in our subject, unlike physics, it is often not clear what is the prime factor, what elements may be omitted in a first approximation. One writer on rent may emphasize distance from the centres of population as the main attribute, and introduce fertility of soil as a perturbation of the abstract result given by the first view. Another fixes attention on the powers of the soil, and allows for other elements, as for friction. So in the theory of money, the state of credit or the quantity of metal have each been regarded as the prime variable.[1] It need not be pointed out how unfavourable to exact science is such a state of the subject-matter. Imagine an astronomer hesitating whether in the determination of Jupiter's movements the sun or the planet Saturn played the most important part. That is the condition of many of our speculations.

It will not be expected that from such materials any very elaborate piece of reasoning can be constructed. Accordingly another point of contrast with mathematical physics is the brevity of our calculations. The whole difficulty is in the statement of our problems. The purely computative part of the work is inconsiderable. Scarcely has the powerful engine of symbolic language been applied when the train of reasoning comes to a stop. The case is like that of the swell in *Punch*, who, about to enter a hansom, inquires solicitously of the driver whether he has got a good horse. "Yes, sir; very good 'oss." "Aw—then dwive to next door." However, our road, though short, is so slippery as to require every precaution.

It follows that in economics, unlike physics, the use of symbols may perhaps be dispensed with by native intelligence. It must be admitted that the correct theory of value has been rediscovered by Menger, and restated by his follower, Böhm-Bawerk, without the explicit use of mathematics. Without the law, they have done by nature the things contained under the law. Still, under a higher dispensation, they might have attained greater perfection. Nor can equal accuracy be ascribed to all the followers of Menger. Nor is the terseness which comes of mathematical study a characteristic of this Austrian school (*m*).

Another point of contrast between the mathematical science of the physicist and the economist is that the former appeals to a larger public. Mathematics is as it were the universal language of the physical sciences. It is for physicists what Latin used to be for scholars; but it is unfortunately Greek to many economists. Hence the writer who wishes to be widely read—who does not say, with the French author, "*J'imprime pour moi*"—will do well not to multiply mathematical technicalities beyond the indispensable minimum, which we have seen reason to suppose is not very large. The parsimony of symbols, which is often an elegance in the physicist, is a necessity for the economist. Indeed, it is tenable that our mathematical constructions should be treated as a sort of scaffolding, to be removed when the edifice of science is completed. As Prof. Marshall, one of the highest authorities on this subject, says: "When a man has cleared up his mind about a difficult economic question by mathematical reasoning, he generally finds it best to throw aside his mathematics and express what he has to say in language that is understanded of the people" (*Academy*, June 1881). Upon this view mathematical discipline might be compared to grammar or to the study of classical literature, which it is profitable to have learnt thoroughly, while it is pedantic to obtrude one's learning.

From these considerations it may appear that our little branch of science is of quite a rudimentary form. The solid structure and regular ramifications of the more developed mathematical sciences are wanting. A less unfavourable contrast would be presented if we compared our method, not with applied mathematics generally, but with that particular branch of it which comes nearest to ours in its proximity to human interests—the use of the calculus of probabilities in social statistics.

There is really only one theorem in the higher part of the calculus, but it is a very difficult one, the theory of errors, or deviation from averages. The direct applications of this theory to human affairs are not very considerable. Perhaps the most conspicuous example is afforded by an investigation to which, if I had undertaken to review the work done in our subjects during the past year, I ought to have directed particular attention—Mr. Galton's rigid proof of the fact and amount of *regression*, or reversion, in children compared with parents, and other relationships.

But, beyond the isolated instances in which the theory of deviations is applied in social statistics with the same strictness and cogency as in physics, there is a wide zone of cases in which the abstract theory is of use as giving us some idea of the value to be attached to statistical results. Mr. Galton justly complains of the statisticians who "limit their inquiries to averages, and do not revel in the more comprehensive views" of the deviations from averages. "Their souls seem as dull to the charm of variety as that of the native of one of our flat English counties, whose retrospect of Switzerland was that, if its mountains could be thrown into its lakes, two nuisances would be got rid of at once." But great caution is required in transferring the theory of errors to human affairs; and the calculus of probabilities may easily be made, in Mill's phrase, the "opprobrium of mathematics."

Now, in all these respects there is a considerable resemblance between the higher parts of the two branches of science which are cultivated in this Section. It may be said that in pure economics there is only one fundamental theorem, but that is a very difficult one: the theory of bargain in a wide sense. The direct application of mathematical reasoning is, as we have seen, limited—more limited, I think, than the corresponding function of the higher statistics. But, on the other hand, the regulative effect, the educational influence, of studies like those of Cournot and Jevons are probably very extensive.

How extensive, it would be difficult to decide without defining the limits of a province within which our special subject is included—the use of abstract reasoning in political economy. Now, on this vexed question, and with reference to the heated controversy between the historical and the deductive schools, the mathematical economist as such is not committed to any side. It may be dangerous to take wide general views; it may be better to creep from one particular to another rather than ascend to speculative heights. Our only question here is whether, if that ascent is to be made, it is better to proceed by the steep but solid steps of mathematical reasoning, or to beguile the severity of the ascent by the zigzag windings of the flowery path of literature. It is tenable that the former course is safest, as not allowing us to forget at what a dangerous height of abstraction we proceed. As Prof. Foxwell has well said,[1] with reference to the mathematical methods in the hands of Jevons and Prof. Marshall, "It has made it impossible for the educated economist to mistake the limits of theory and practice, or to repeat the confusions which brought the study into discredit and almost arrested its growth."

I trust that I have succeeded in distinguishing the question what is the worth of abstract reasoning in political economy from the much more easily answered question whether, if it is worth doing, it is worth doing well.[2] The mathematical economist is concerned to separate his method from that mathematical and metaphysical reasoning which Burke repudiates as inapplicable to human affairs; from that abstract method which he has in view when he says:—"Nothing can be more hard than the heart of a thoroughbred metaphysician. It comes nearer to the cold malignity of a wicked spirit than to the frailty and passion of a man" ("Letters on a Regicide Peace"). Burke is referring to the Jacobin philosophers; but our withers are unwrung, if similar words should be applied to some of the "sophisters and economists" of a later generation. Just as a political party, if

[1] Compare Cournot: "Ce que l'un néglige dans une première approximation comme un fait secondaire et accessoire, un autre le regardera comme le fait principal et dominant" ("Principes," book iv. chap. vii.).

[1] In his important letter on "The Economic Movement in England" in the *Quarterly Journal of Economics* for October 1888.

[2] Cf. Prof. Foxwell. *loc. cit.*:—'What the new school protest against is first the unscientific and meagre way in which deduction was used. In their view, though it is worth while to study, and therefore worth while to study accurately, the workings of private interest under a system of competition, yet human nature is not all self-interest. . . ."

popularly suspected of complicity with crime, would do well to take every opportunity of clearing themselves from that imputation, so the mathematical economist is called on to disown emphatically all sympathy with the flagrant abuses to which the injudicious use of abstract reasoning is undoubtedly liable.

To continue the comparison which I was instituting between the mathematical theory of economics and the calculus of probabilities, they have one very unpleasant property in common—a liability to slips. As De Morgan says,[1] "Everybody makes errors in probabilities at times, and big ones." He goes on to mention a mistake committed by both Laplace and Poisson, the ineptitude of which he can only parallel by the reasoning of a little girl whom he had called a "daughter of Eve"; to which she retorted, "Then you must be a daughter of Adam." It is not to be concealed that economic reasoning, even in its severest form, is sometimes equally inconsequent. I should have hesitated to assert that Cournot has made some serious mistakes in mathematics applied to political economy, but that the authority of the eminent mathematician Bertrand[2] may be cited in support of that assertion.

Again, the more abstract theories of value and of probabilities seem to resemble each other in their distance from the beaten curriculum. Each forms, as it were, a little isolated field on the rarely crossed frontier and almost inaccessible watershed between the moral and the physical sciences.

The same character of remoteness belongs perhaps to another province, which is also comparable with ours—the mathematical side of formal logic, the symbolic laws of thought which Boole formulated. There was a certain congruity between Jevons's interest in his logical machine and in what he called the "mechanics of industry." But I venture to regard the latter pursuit as much more liberal and useful than any species of syllogism-grinding.

If you accept these parallels, you will perhaps come to the conclusion that the mathematical theory of political economy is a study much more important than many of the curious refinements which have occupied the ingenuity of scientific men; that as compared with a great part of logic and metaphysics it has an intimate relation to life and practice; that, as a means of discovering truth and an educational discipline, it is on a level with the more theoretical part of statistics; while it falls far short of mixed mathematics in general in respect of that sort of pre-established harmony between the subject-matter and the reasoning which makes mathematical physics the most perfect type of applied science.

But we must remember—and the mention of the theory of probabilities may remind us—that any such judgment is liable to considerable error. We cannot hope to measure the utility of a study with precision, but rather to indicate the estimate on either side of which competent judges would diverge—a central point, which will be found, if I mistake not, equally removed from the position of Gossen, who compares the new science to astronomy, and the attitude of Dr. Ingram towards the researches which he regards as nothing more than "academic playthings, and which involve the very real evil of restoring the metaphysical entities previously discarded."[3]

One more general caution is suggested by another of the technical terms which we have employed. What we are concerned to discover is not so much whether mathematical reasoning is useful, but what is its "final utility" as compared with other means of research. It is likely that a certain amount of mathematical discipline—say as much as Mr. Wicksteed imparts in his excellent "Alphabet of Economic Science"—is a more valuable acquisition to a mind already stored with facts than the addition of a little more historical knowledge.

But, in reverting to the subject of final utility, I am reminded that Presidential addresses, like other things, are subject to this law; and that a discourse on method prolonged beyond the patience of the hearers is apt to become what Jevons called a *discommodity*.

[1] Writing to Rowan Hamilton ("Life of Hamilton," by R. Graves, vol. iii.).

[2] *Journal des Savants*, 1883. I hope to show on some future occasion that M. Bertrand's censures of Cournot and Prof. Walras are far too severe.

[3] See the passage relating to Jevons in the article on "Political Economy" in the "Encyclopædia Britannica," ninth edition.

NOTES.

(*a*) SIMPLE EXCHANGE.—The simplest case of exchange is where there are two large groups of uncombined individuals dealing respectively in two commodities, *e.g.* corn and money. To represent the play of demand and supply, let any abscissa, Ox in Fig. 1, represent a certain price, and let the quantity of commodity demanded at that price be xp. The locus of p may be called the demand-curve. Similarly, xq represents the quantity offered at any price, Ox; and the locus of q is called the supply-curve. The price Oa, at which the demand is just equalled by the supply, is determined by the intersection of these curves. This is Cournot's construction. The converse construction, in which the abscissa stands for quantity of commodity, the ordinate for price, is employed by Mr. Wicksteed in his excellent "Alphabet of Economic Science."

The diagrammatic representation which most closely corresponds to Jevons's formulæ is that which the present writer, after Prof. Marshall, and Messrs. Auspitz and Lieben, independently, has adopted. In this construction the two coordinates respectively and symmetrically represent the quantities

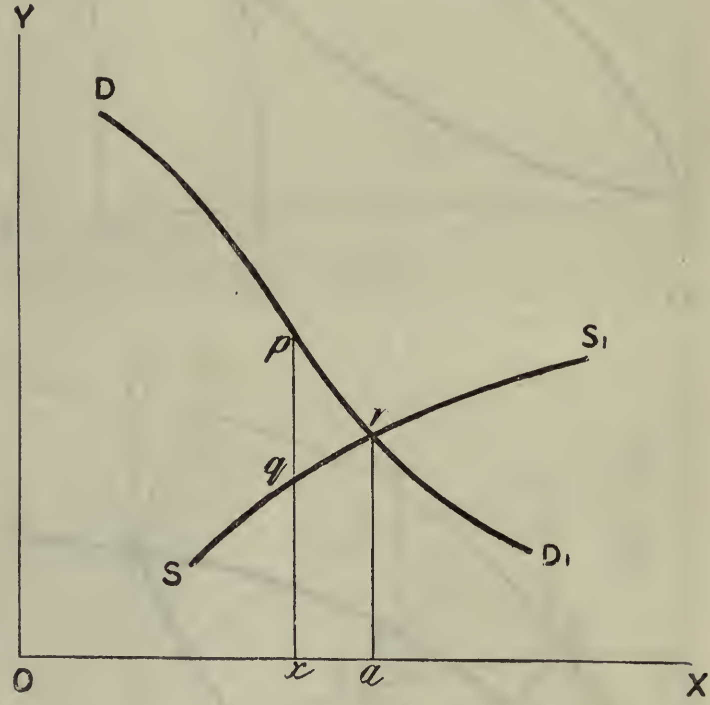


FIG. 1.

of the two commodities exchanged, the *quid* and the *pro quo*. For instance, Fig. 2 may represent the state of supply and demand in the international market between Germany and England. The curve OE denotes that in exchange for any amount of "linen," Oy, England is prepared to supply the quantity of "cloth" yp (= Ox); or, in other words, that in exchange for the quantity Ox of cloth England demands xp (= Oy) of linen. The curve OG is similarly related to Germany's supply and demand. The position of equilibrium is determined by the intersection of these curves.

(*b*) VARIATIONS IN SUPPLY.—Suppose, as Mill supposes ("Pol. Econ.," book iii. ch. xviii. § 5), that there has occurred an improvement in the art of producing Germany's export, linen. The altered conditions of supply may be represented by the displaced curve OG′, Fig. 3, indicating that, whereas before the improvement Germany in exchange for any quantity, Ox, of cloth offered only xq, she now offers xq'. The effect of the improvement on the rate of exchange will depend upon the form of the curve OE beyond the point r. If the intersection of the curve OE is at r; vertically above r, we have the case where, as Mill rather awkwardly says, the demand of England for linen increases "in the same proportion with the cheapness." The other cases in which the demand for linen—and accordingly the price, so to speak, of cloth in linen—are increased more or less than the cheapness, are represented by the points of intersection r_2, r_3.

The same construction may be used to represent the effect on the rate of exchange produced by a tax on exports or imports. Let OG′ now represent the undisturbed condition of supply, and let OG be what this curve becomes when displaced by a tax on Germany's exports. According to the position of the original intersection, whether at r_1, r_2, or r_3, we have the three cases distinguished by Mill (book v. ch. iv. § 6).

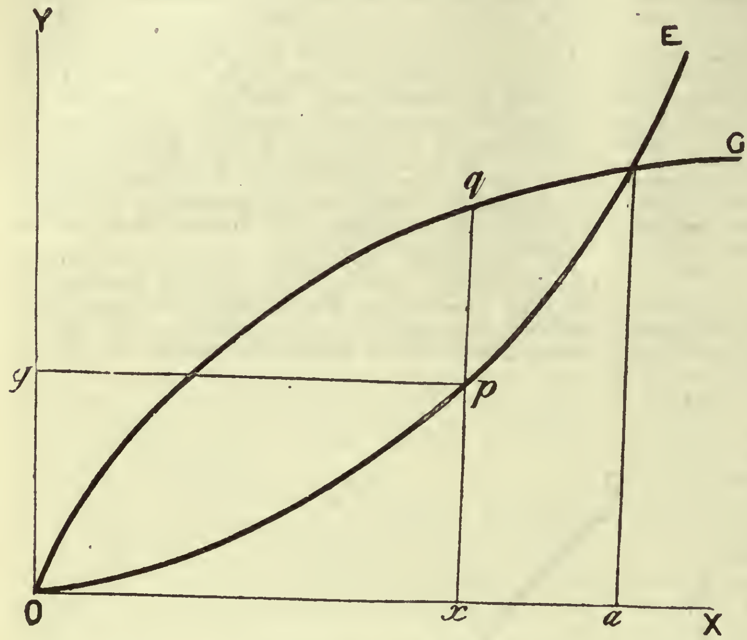


FIG. 2.

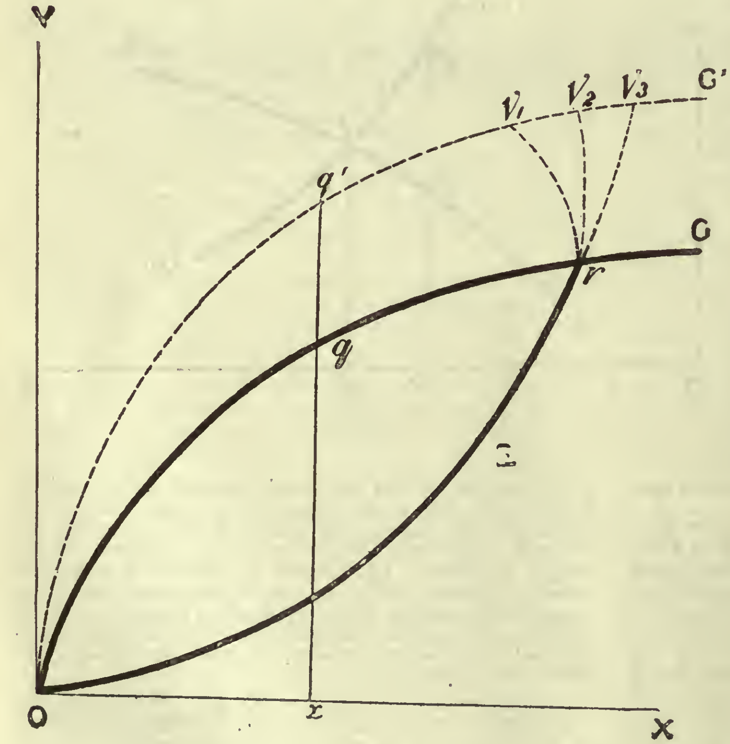


FIG. 3.

Again, the same construction may be used to facilitate the comprehension of international trade which Prof. Sidgwick has recently proposed. Let the curves OE and OG′ represent the conditions of supply and demand, on the hypothesis that cost of transport is annihilated, that England and Germany are in juxtaposition. Now restore the abstracted sea, and the altered conditions of supply and demand *in a market on the English shore* will be represented by the change of OG′ to OG. According to the form of the curve OE the different effects on the rate of exchange are visible at a glance. (Cf. Sidgwick, "Pol. Econ.," book ii. ch. ii. § 3)

(*c*) GAIN OF TRADE.—To measure the variations in the advantage acruing from trade by the variations of price—or more generally, rate of exchange—is a confusion which could hardly have occurred to the mathematical economist. The simplest method of illustrating the gain of trade is that proposed by Messrs. Auspitz and Lieben. In Fig. 4, let On be the *locus* of a point t, such that a certain individual in exchange for the quantity Ox of one commodity will just be willing to give the quantity tx of another commodity, will neither gain nor lose by that bargain. Then, if he obtain Ox in return for only rx, he is a gainer by that bargain to the extent of tr. The curve thus defined is called the *utility-curve*.

Now add properly the utility-curves for all the individuals of a community, and we obtain what may be called a collective utility-curve. There is a peculiar propriety in taking one axis, say the ordinate, to stand for money. Let ON, then, in Fig. 5, be the collective utility-curve, in this sense, for the German community with respect to cloth. Let OG represent the demand of Germany for cloth, as before, except that the ordinate now stands for money, not linen. And let OE represent the supply of cloth in exchange for money on the part of England. Then the gain to Germany of the trade with England is represented by the vertical distance tr.

Now let Germany impose a tax on the import of cloth. The effect of the tax will be to displace the supply-curve in the manner indicated by the dotted curve OE′. Let r' be the new point of intersection between the demand- and (displaced) supply-curve. The gain to Germany in the way of trade is now $t'r'$. To which is to be added the tax r'S accruing to Germany. Since t'S may very well be greater than tr, Germany may gain by the imposition of the tax.

What difficulties the reader may feel about this proposition will disappear on reference to Messrs. Auspitz and Lieben's beautiful and original reasoning ("Theorie der Preise," §§ 80–82). In the light of their constructions it will be at once seen what conditions of supply and demand are favourable to the endeavour of one nation to gain by taxing the imports from (or exports to) another. It will be noticed that the particular supposition entertained by Prof. Sidgwick (book iii. ch. v. § 2)—that the quantity consumed of the taxed import is constant—is not essential.

It may be observed that the *utility-curve* is a particular case of the "*indifference-curve*" employed by the present writer ("Mathematical Psychics," p. 21). Also the lines *tr* and *t'*S are particular cases of the "preference-curve" (*ibid.* p. 22). If these more general conceptions are employed, the demonstration will not require that we should put the ordinate for money, regarded as a constant measure of utility. The interpretation assigned to the curves OG and OE in our second and third figures may still stand.

(*d*) ECONOMIC EQUILIBRIUM.—By analogy with well-known physical principles, economic equilibrium may be regarded as determined by the condition that the advantage of all parties concerned, the integrated utility of the whole economic system, should be a *maximum*. This *maximum* is in general subject, or in technical phrase *relative*, to certain conditions; in particular what Jevons called the "law of indifference," that in a market all portions of a commodity shall be exchanged at the same rate. But occasionally this condition is suspended; as often as we take what may be called a socialistic or utilitarian view as distinguished from that incommensurability of pleasures appertaining to different persons, which Jevons in a remarkable passage of his "Theory" (p. 15) has postulated. It will be found that this postulate must be abandoned when we consider the gain of trade, as in our note (*c*), or the theory of combinations, as in note (*l*), and on other occasions.

In general, the first condition of a maximum, that the first term of variation should vanish, gives the Jevonian equations of exchange, the demand-curves of other writers.

The second condition of a maximum, that the second term of variation should be negative, finds its fulfilment in certain well-known propositions which involve the conception of a decreasing rate of increase, viz. the law of diminishing returns, the law, or laws, of diminishing utility and increasing fatigue.

For some propositions it is proper to take account not only of the sign, but also the magnitude, of the second differential of utility. Thus, when Prof. Walker is contending that in case of "any increase of product resulting from the introduction of any new force into industry," the whole increment will fall to be added to the share of the working class, he argues, quite correctly upon his premises, that if the improvement does not "increase the amount of tools and supplies required in production"—since "there is no greater demand for capital in the case supposed— . . . there can be no increase in the rate or amount of interest" (*Quarterly Journal of Economics*, 1887, pp. 283, 284). Analytically we should find that the variation in the rate of interest due to the disturbance of the equilibrium, say $\Delta\iota$, was indefinitely small as compared with the variation in the rate of wages, say $\Delta\omega$, because the decrease in the rate at which the utility of capital increases is indefinitely great. The argument requires that this second differential should be infinite at the position of equilibrium—a postulate which may perhaps give us pause.

(*e*) COMPLEX EXCHANGE is the general case of simplex exchange above analyzed. We have now several, instead of two, categories of dealers and commodities. In both cases equilibrium is determined upon the principle that each individual seeks to maximize his own advantage, subject to the conditions (1) that in a market there is only one price for any article, and (2) that all which is bought is sold, and all which is sold is bought. Let there be *m* dealers and *n* articles. And the first article being taken as the measure of value, let the prices of the remaining articles be $p_2, p_3, \ldots p_n$. Let the quantities of commodities bought or sold by any individual, say No. *r*, be $x_{r1}, x_{r2}, \ldots x_{rn}$; each variable with its sign: *plus*, if bought, *minus*, if sold. Let the advantage of the individual, regarded as a function of his purchases and sales, be $\psi_r(x_{r1}, x_{r2} \ldots x_{rn})$. There is sought the system of values assigned to the variables for which this function is a maximum, subject (α) to the condition which follows from

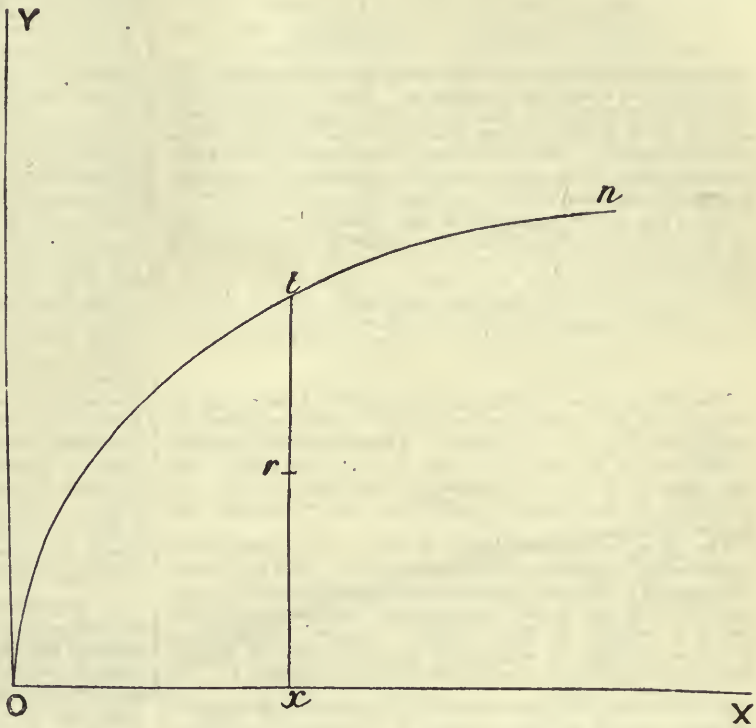


FIG. 4.

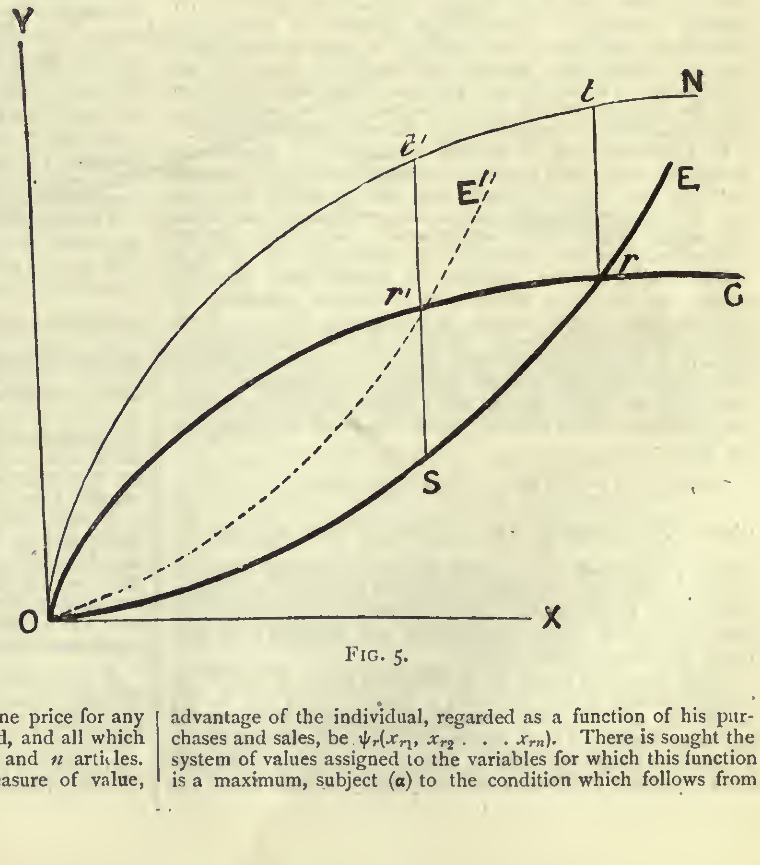


FIG. 5.

the first assumption above made: $x_{r1} + p_2x_{r2} + \&c. + p_nx_{rn} = 0$. In order to determine the maximum of ψ_r subject to this condition, we obtain (β) by the calculus of variations $(n - 1)$ equations of the form—

$$\left(\frac{d\psi_r}{dx_{r1}}\right)=\frac{1}{p_2}\left(\frac{d\psi_r}{dx_{r2}}\right)= \ldots = \frac{1}{p^n}\left(\frac{d\psi_r}{dx_{rn}}\right)$$

(with certain conditions as to the second term of variation). To which is to be added the equation (α). We have thus n equations relating to the rth individual. The same being true of each of the m individuals, we have in all mn equations of the forms (α) and (β). We have also (γ), from the condition that everything which is bought is sold, and conversely, n equations of the following form: $x_{1s} + x_{2s} + \&c. + x_m = 0$.

But of the $(m + n)$ equations of the forms (α) and (γ) only $(m + n - 1)$ are independent. For adding the m equations of the form (α) we have:—

$$\left.\begin{array}{l}(x_{11} + x_{21} + \ldots + x_{m1}) \\ + p_2(x_{12} + x_{22} + \ldots + x_{m2}) \\ + \quad — \quad — \quad — \quad — \\ + p_n(x_{1n} + x_{2n} + \ldots + x_{mn})\end{array}\right\} = 0.$$

Now, if any $(n - 1)$ of the equations of the form γ, say all but the first, are given, then in the last written equation the coefficients of $p_2 \ldots p_n$ vanish. Therefore the first equation of the form (γ), viz. $x_{11} + x_{21} + \&c. + x_{m1}$, is also given. We have thus $mn + (n - 1)$ equations to determine $mn + (n - 1)$ quantities, viz. the x variables, which are mn in number, and the $(n - 1)$ p's.

The great lesson to be learnt is this. The equations are *simultaneous*, and their solutions *determinate*. That the factors of economic equilibrium are simultaneously determined is a conception which few of the literary school have received. The reader is referred to Prof. Walras's "Leçon" 12 ("Econ. Pol.," second ed.) for a lengthier exposition, and for a more accurate one to Messrs. Auspitz and Lieben's Appendix IV.

(*f*) COMMERCIAL COMPETITION.—Abstracting that change of occupations which Cairnes ascribed to "industrial" as distinguished from "commercial" competition (comp. Sidgwick's "Pol. Econ.," book ii. ch. i.), let us suppose that the x's of the last note, which primarily denoted commodities ready for immediate consumption, include also agencies of production: (the use of) land, labour, and capital. We may conceive *entrepreneurs* buying these agencies from landlords, labourers, and capitalists, and selling finished products to the public. We have thus the appropriate idea of rent, wages, interest, and (normal) prices determined *simultaneously* (in the mathematical sense).

In a primary view of complex exchange it is proper, with Jevons, to regard each portion of commodity sold, each negative variable, say $-x_{rs}$, as a deduction from an initial store, say ξ_{rs}. But when we consider production, we regard ξ as a function of the outlay of the *entrepreneur*. Supposing that the *entrepreneur* confines himself to the production of a single article, let the gross produce, in money, after replacing capital, be $f_r(c_r, l_r)$, where f_r is a function depending on the individual's skill, energy, opportunities, &c., c_r is the amount of capital borrowed by him, and l_r the number of acres of a certain quality which he rents. The net produce is obtained by deducting from this quantity the payments $c_r\iota - l_r\rho$, where ι is the rate of interest and ρ is the rent per acre. Thus the advantage which the *entrepreneur* seeks to maximize is of the form—

$$\psi_r(x_{r1}, x_{r2} \ldots [f_r(c_r, l_r) - c_r\iota - l_r\rho] - x_{rr}p_{rr}, \ldots).$$

whence $\frac{df_r}{dc_r} = \iota$ and $\frac{df_r}{dl_r} = \rho$. The first of these equations expresses a well-known proposition regarding the final utility of capital. The second equation expresses a less familiar condition with respect to the number of acres which will be rented on an ideal supposition of the homogeneity and divisibility of land above the margin of cultivation.

What, then, and where, is the Ricardian theory of rent? Its symbolic statement is $l_r\rho = f(c_r, l_r) - f(c_r, o) = f_r(c_r, l_r) - c_r \times \iota$; where $f(c_r, o)$ is the gross produce of c_r capital laid out by the individual numbered r, on land below the margin obtainable for nothing in as large quantities as desired. It will be found that these equations postulate that the quantity of land above the margin is small as compared with the number of applicants, and that $f(c_r, o)$ is identical with $c_r \times \iota$, which are the common Ricardian assumptions. The validity of these assumptions as a first approximation, the need of correction where greater accuracy is required (truths which some minds seem incapable of holding together), have been admirably pointed out by Mr. Sidgwick ("Pol. Econ.," book ii. ch. vii. § 2). The second approximations made by him may be usefully expressed in the symbols which have been proposed, or rather in those which the student may construct for himself. I do not put forward those which occur to me as the best—if, indeed, there is any absolutely best in the matter of expression. For some purposes it would have been proper to take account of the various qualities of land (as I have elsewhere done—"Brit. Assoc. Rep.," 1886). For other purposes it would be well to put labour hired by the *entrepreneur* as an independent variable. When this or any other variable is omitted, we are to understand that there is implied the best possible arrangements with respect to the variables which are not expressed. The nature of this implication is shown in the following note.

(*g*) So far we have been taking for granted that the *entrepreneur* does his best, without reference to the motives acting upon him, the pleasures procurable by the sale of his product. Formally it would be proper to take account that the utility-function ψ_r involves the *effort*, say e_r, explicitly, as fatigue diminishes advantage, and implicitly, as exertion increases production. Corresponding to the new variable we have a new equation, the complete differential of ψ_r with reference to e_r, say $\left(\frac{d\psi_r}{de_r}\right) + \left(\frac{d\psi_r}{df_r}\right)\frac{df_r}{de_r} = 0$. It is a nice question how far effort should be regarded as an independent variable; how far the essential principle of piece-work prevails in modern industry.

(*h*) INDUSTRIAL COMPETITION.—The condition that net advantages should be equal in industries between which there is mobility may thus be contemplated. Let us put the advantage of an individual, say No. r, engaged in the occupation s as a function of his net income, the price of the articles in which his expenditure is made, and the disutility of effort. Say $\phi_{rs}(\mathfrak{f}_{rs}(\pi_1, \pi_2 \ldots e_{rs}), p_1, p_2 \ldots - e_{rs})$; where ϕ_{rs} is a utility-function, not necessarily the same for the same individual in different occupations, since his indulgences may vary with the nature of his employment; $\mathfrak{f}_{rs}$—a symbol not identical with the f of the last but one note—is the individual's net earnings in the business s, involving prices π_1, π_2, &c., of all manner of agents of production, involving also, as stated in note (*g*), the effort e_{rs}; p_1, p_2, &c., are prices of articles of consumption as a function of which the individual's advantage may be obtained by means of the equations (α) and (β) in note (*e*)—eliminating the quantities consumed. The last variable in the function ϕ_{rs}, the explicit e_{rs}, has a negative sign prefixed, to indicate that the direct effect of increased fatigue is diminished advantage.

The equation of net advantages imports that the advantage, ϕ_{rr}, of the occupation which the individual chooses is not less than ϕ_{rs}, the advantage of any other occupation open to him. It is important to observe that for all occupations the complete differential with regard to e is zero; in symbols $\left(\frac{d\phi}{d\mathfrak{f}}\right)\frac{d\mathfrak{f}}{de} + \left(\frac{d\phi}{de}\right) = 0$.

But this equation conveys no presumption that the final disutility in different occupations is the same that $\left(\frac{d\phi_{rs}}{de_{rs}}\right) = \left(\frac{d\phi_{rt}}{de_{rt}}\right)$.

The equation of final disutility holds only where efforts and sacrifices are capable of being applied in "doses" to any number of occupations. The latter is the only case, I think, contemplated by Jevons in his analysis of cost of production ("Theory," ch. v.). The inquiry, what is meant in general by saying that the cost of production of two articles is equal, must start from right conceptions about final and total utility. But this is not the place to follow up the difficult investigation. I do not attempt here to discuss any matter fully, but only to illustrate the suitability of the subtle language of mathematics to economical discussions.

(*i*) PROF. WALKER'S THEORY OF BUSINESS PROFITS.—Prof. Walker's theory as stated in the *Quarterly Journal of Economics* for April 1887, involves the proposition that the remuneration of the lowest, the least gifted employers, is on a level with that of the labouring class. Concerned as we are here with methods rather than results, it is allowable to posit this premise without expressing an opinion as to its accuracy. It is fortunate not to have to take sides on an issue concerning which the highest authorities are divided, and statistical demonstration is hardly possible.

But, though the expositor of method is not called to dispute the truth of this proposition, he has something to say against the evidence which has been adduced in proof of it. He must enter a protest against the form of the following argument :—

"Let our hypothesis be clearly understood. We assume, first, that there is in a given community a number of employers, more or fewer, who alone are, by law or by custom, permitted to do the business of that community, . . . or else who are so exceptionally gifted and endowed by Nature for performing this industrial function that no one not of that class would aspire thereto, or would be conceded any credit or patronage should he so aspire. Secondly, we assume that neither in point of ability nor opportunity has any one member of this class an advantage as against another, . . . all being, we might say, the exact copies of the type taken, whether that should involve a very high or a comparatively low order of industrial power.

"Now, in the case assumed, what would be true of business profits, the remuneration of the employing class? I answer, that if the members of this class were few, they might conceivably effect a combination among themselves, and . . . fix a standard for their own remuneration. . . . If, however, the community were a large one, and if the business class . . . were numerous, such a combination . . . would be impracticable, . . . the members of the business class would begin to compete with each other. From the moment competition set in it would find no natural stopping-place until it had reduced profits to that minimum which, for the purposes of the present discussion, we call *nil*.

"What, in the case supposed, would be the minimum of profits? I answer: This would depend upon an element not yet introduced into our problem. The ultimate minimum would be the amount of profits necessary to keep alive a sufficient number of the employing class to transact the business of the community. Whether, however, competition would force profits down to this low point would depend on the ability or inability of the employing class to escape into the labouring class. We have supposed that labourers could not become employers; but it does not follow that employers might not become labourers and earn the wages of labourers. . . ." (*Quarterly Journal of Economics*, 1887, p. 270 and context).

This reasoning will puzzle those who have received the abstract theory of supply and demand as formulated by the mathematical section [above, notes (*a*) and (*d*)]. Because the dealers on one side of a market, as the employers in the labour market, compete against each other without combination, it does not follow that the advantage which they obtain from their bargains is *nil*. The minimum to which the play of competition tends is not necessarily small in the sense of a bare subsistence. It is a minimum only in the mathematical sense in which every position of equilibrium is a minimum (of potential energy in physics; in psychics, may we say, of potential utility). See note (*d*).

Representing the *entrepreneur's* demand for work by the curve OG (Fig. 5), where the abscissa measures work done, and the ordinate money payable out of the wages and profit fund, and putting OE for the offer of the workmen, we see that the point *r* may differ to any extent from the utility-curve ON, which indicates the advantage of a transaction [see note (*d*)]. As far as abstract theory, without specific data, carries us, the competing *entrepreneurs* may make very good bargains. They may be ever so prosperous; they may be, in Burke's fine phrase, "gambolling in an ocean of superfluity."

So far, on the hypothesis that neither in point of ability nor opportunity has any one member of this class an advantage as against another. The heterogeneity of faculty will, of course, introduce a graduation of gain. But in this flight of steps it is not necessary that the lowest should be on a level with the grade of common labour. The scale of profits may be a sort of Jacob's ladder, culminating in a paradise of luxury, and having its lowest rung suspended high above the plain of ordinary wages.

Let us suppose, however, that the writer has tacitly made some assumption as to the numbers of the "numerous" business class relatively to the "large" community (compare the parallel passages in his "Political Economy," Arts.). Still, what does the consideration of business profits as rent do more than the received principle of supply and demand? If the workmen, believing that in the distribution regulated by competition too much has been assigned to brain and too little to muscle, determine to reduce profits by means of a combination, should they stay their hand because they are told that profits (above the lowest grade) are of the nature of rent? The terms "rent" and "margin" may indeed suggest that the extra profits of the abler *entrepreneurs* exactly correspond to their greater ability. It might seem that if, so to speak, we pushed down all the higher faculties to the level of the lowest grade of business power, the diminution of

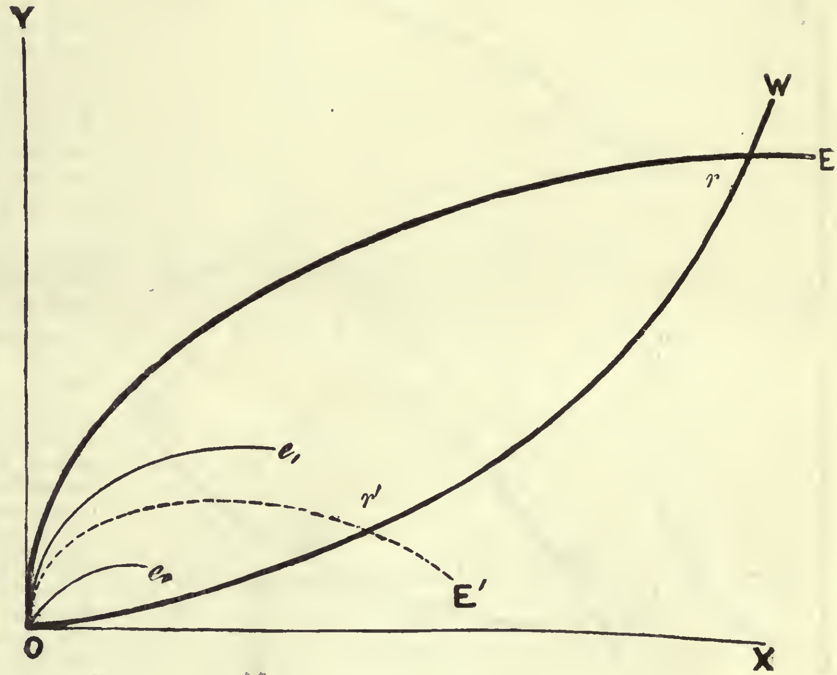


Fig. 6.

the total distributed to the wages and profits fund would exactly correspond to the subtraction from the earnings of the degraded *entrepreneurs*, while everything else remained constant. Conversely, it might be argued that the increment of produce due to the existence of superior ability may justly be assigned as extra profit.

But how little appropriate is this precise conception will at once appear from the annexed diagram. Let OE in Fig. 6 represent the *entrepreneur's* demand, OW the workmen's offer of labour, the abscissa representing work done, and the ordinate wages payable out of the wages and profits funds (abstraction being made of interest and rent for land). Let OE be formed by the superposition of Oe_0, the demand-curve for the lowest collective *entrepreneurs*, and one or more curves, such as Oe_1, appertaining to the *entrepreneurs* of higher ability. Now let us shrink these higher natures to the zero of business ability. The individual demand-curve for each degraded *entrepreneur* will become identical with that from which Oe_0 was formed (by the combination of all the demand curves for the lowest grade). The new demand-curve will therefore be of the form OE′ intersecting with OW at the point r'. (Whether the disturbance will stop there will depend upon the nature of the communication between the departments of employer and workman; whether the mobility is one-sided, like that of fluid allowed by a valve to escape from one vessel to another, but not back again—see the end of the passage cited on p. 505 from the *Quarterly Journal of Economics*—or whether the permeation is perfect.) If Oe_0 is small, if the part played in production by the marginal employers is insignificant, it is probable that the annihilation of the higher grades will result in the destruction of the greater part not only of profits, but also of wages.

Accordingly it appears, in general, inexact to say that the "surplus which is left in the hands of the higher grades of employers . . . is of their own creation" (*Quarterly Journal of Economics*, April 1887, p. 274); if we define their own creation as the difference between the actual produce and that which would have existed if their superior faculties had not been exercised. In that sense (and what other sense is there?) the surplus of the higher grades is likely to be much *less* than their own creation (especially in the case where the marginal employers are relatively few). We seem to have proved too much. But may we not deduce the *quod est demonstrandum*, that actual profits are deserved, from the larger proposition that the *entrepreneurs'* "own creation" is by a certain amount greater than their profits? No; for that larger proposition is blocked by the antinomy that the workmen (or the higher grades of them may by parity claim the greater part of the produce as *their* "own creation"—what would not have existed but for the exertion of their faculties.

In short, we know no more than we knew at first—viz. that the distribuend is produced jointly by the owners of brain and muscle, that the terms of the distribution are determined by supply and demand, and that in this, as in every other market, each more favoured nature enjoys a *rent*, or differential advantage [the nature of which is well illustrated by Messrs. Auspitz and Lieben's construction indicated in our note (*c*)]. That the surplus earning of the superior *entrepreneur* is his own creation is true of the individual, but not of the class; in division, but not in composition.

However, Prof. Walker may have tacitly made some specific assumptions as to the quantities involved (*e.g.* the proportion of produce with which the marginal *entrepreneurs* are concerned); or I may have misinterpreted his statements. Even so, the liability to such misconstruction is a defect in the purely literary method.

It would be easy in the case of less eminent writers to exemplify the part which the mathematical *organon* may play in lopping the excrescences of verbal dialectics. But I must content myself with briefly adverting to one of Prof. Walker's critics, Mr. Sidney Webb. His able paper on the "Rate of Interest and the Laws of Distribution" appears to me to contain several points deserving of attention; with respect to which mathematical conceptions may assist the reader in distinguishing the original from the familiar, and the true from the misleading.

(1) Mr. Webb restates the theory formulated by Jevons, that capital is ideally distributed according to the law of "equal returns to the last increments" ("Rate of Interest and Laws of Distribution," by S. Webb, pp. 10, 11, 21 of paper reprinted from *Quarterly Journal of Economics*, January 1888).

In symbols [see above, note (*f*), p. 504] let the net earning of any individual be $f_r(c_r) - \iota c_r$; where f_r is a function differing for different individuals according to their faculties and opportunities, c_r is the amount of borrowed capital employed by the individual; ι is the rate of interest; land and labour are not expressed. In equilibrium,

$$\frac{df_r(c_r)}{dc_r} = \iota = \frac{df_s(c_s)}{dc_s} = \frac{df_t(c_t)}{dc_t} = \dots$$

(2) Again, Mr. Webb discerns that the "law of diminishing returns" is applicable to capital as well as to land (*ibid.*, pp. 9, 20, &c.). This is probably a new truth to the literary economist, who will have some difficulty in reconciling it with the *law of increasing returns* received into the text-books. To the mathematician it is evident that, in order to maximize the net earnings $f(c) - \iota c$, not only must the first differential of this expression vanish, but also the second differential, $\frac{d_2 f}{dc^2}$, must be negative, which is the *law of diminishing returns* It is quite consistent with the supposition that for certain values of the variable, not admissible as a solution of the problem, $\frac{df}{dc}$ should be positive, agreeably to the *law of increasing returns*.

Diagrammatically, let us represent the conditions under which capital is applied by a certain individual, according as the scale of production is large or small, by the curves pq and $p'q'$ in Fig. 7; where the abscissa denotes quantity of capital, and the ordinate the increment of (gross) produce due to an increment of capital. There cannot be equilibrium, unless the increment denoted by the ordinate is just balanced by the sacrifice thereby incurred—in the case which I have supposed, the payment of interest. There cannot, then, on this supposition, be stable equilibrium, unless the curve is ascending. The descending (dotted) branches correspond to the law of increasing returns. (The explanation of other features in the figure is given in the next note.)

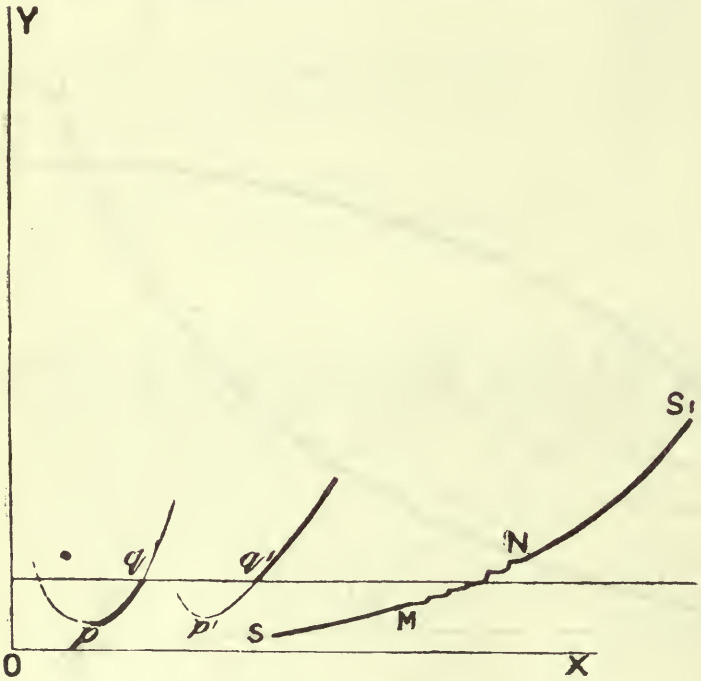


FIG. 7.

(3) Mr. Webb dwells much on "the special industrial advantages not due to superiority of site or skill" which are enjoyed by some individuals. The use of an expression for the product like our f_r may serve at least to keep in mind the existence of such specialities. It also brings into view a difficulty which has not been sufficiently noticed by those who use *rent* in its metaphorical or secondary sense.

Suppose the extra produce is a function involving several variables (or parameters) like land, ability, opportunity. Say, $f_r = F(\lambda, \alpha, \omega \dots)$, where F is a form common to the community, and λ, α, ω denote the quality of land, ability, and opportunity peculiar to the individual. If the extra produce is $F(\lambda, \alpha, \omega) - F(o, o, o)$; is $F(\lambda, o, o) - F(o, o, o)$ the "economic rent" of land; $F(o\ \alpha\ o) - F(o, o, o)$ the rent of ability; $F(o\ o\ \omega) - F(o\ o\ o)$ the extra produce due to opportunity? (*ibid.*, pp. 16, 17). If so, the three parts do not make up the whole.

(4) Anyway, to call the third extra produce *interest* is very unhappy. Its affinities are evidently with rent (cf. Sidgwick, "Pol. Econ.," book ii. ch. vii. § 4).

(5) I should not have complained about the use of a term, but that it is connected with Mr. Webb's main contention against Prof. Walker, to which I am unable to attach significance:

that "this, not the 'rent of ability,' is the real keystone of the arch" (*ib.*, p. 17). From the point of view here taken (above, p. 497) this search for the "keystone" among the factors of distribution is nearly as hopeless as the speculation of the ancients about the real *up* or *down*.

(*j*) DETERMINATENESS OF ECONOMIC EQUILIBRIUM.—To investigate the possibility of there being more than one rate of exchange at which the supply is just carried off by the demand, let us consider the most favourable or, at least, the most familiar case in which there may be two scales of production, and therefore two series of terms on which the producer is willing to deal—two supply-curves. Let the two branches in Fig. 7 represent such a double supply-curve, the ordinate denoting price, and the abscissa the quantity of product which is offered at that price by a certain individual. Now, the essential idea or leading property of an individual supply-curve is that it represents the quantity which the individual will prefer to offer at any given price. Hence the *descending* part of the branches, dotted in the figure, cannot form a genuine supply-curve. For at any point on that part of the *locus* it is evidently the interest of the individual to increase his production, price being constant. Stable equilibrium, therefore, can exist only on the ascending, the unbroken branches. The thick curve lines in the figure indicate the *locus* of *greatest possible*, as distinguished from *maximum*, utility. Suppose that at and above the price, corresponding to the point q, it is the interest of the producer to adopt the larger scale of production. Up to that price his industrial dispositions will be represented by the inner curve; on reaching that point he will jump from q to q' and ascend along the outer curve. The *locus* of greatest possible utility may be called the genuine or effective supply-curve. A similarly shaped supply-curve may exist for other producers. Suppose, now, all these individual effective supply-curves superposed, and we have the effective supply-curve for the community, SS^1, which continually trends outwards. This character is not annulled by the existence of steps in the tract MN, corresponding to the prices at which the leap of each individual occurs. *A fortiori* the demand-curve continually trends outwards like that in Fig. 1 (cp. Auspitz and Lieben). It should seem, therefore, that theoretically on the supposition of enlightened self-interest there is only one rate of exchange at which supply is just equal to demand. No doubt there is something to be said on the other side. Suppose the jump from q to q', or from q' to q, involves a breach of habit, the inconvenience which the "economic man" will not neglect. A little attention will show that in this case the tract MN′ of the collective-curve might break up in two separate branches. Moving from M upwards we should not be on the same *locus* as from N downwards.

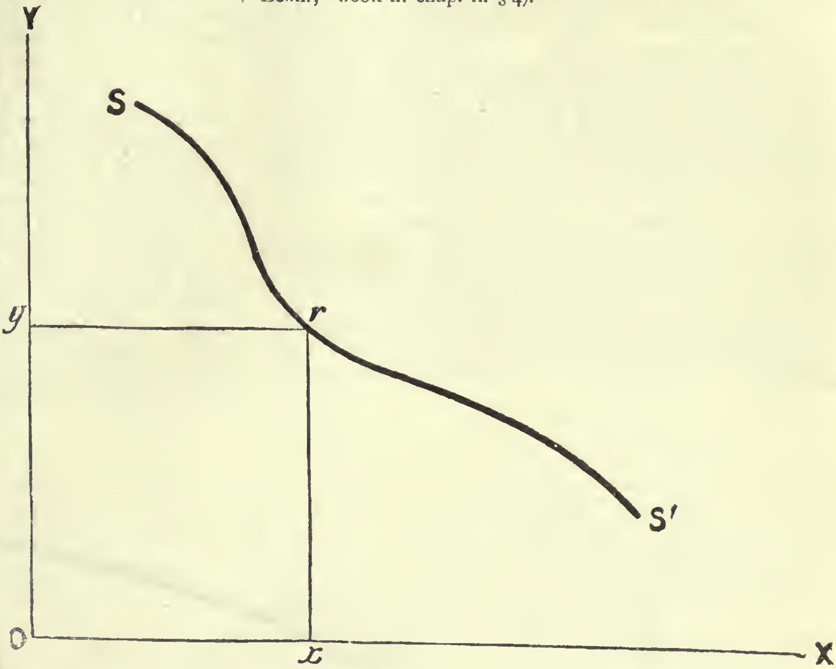


FIG. 8.

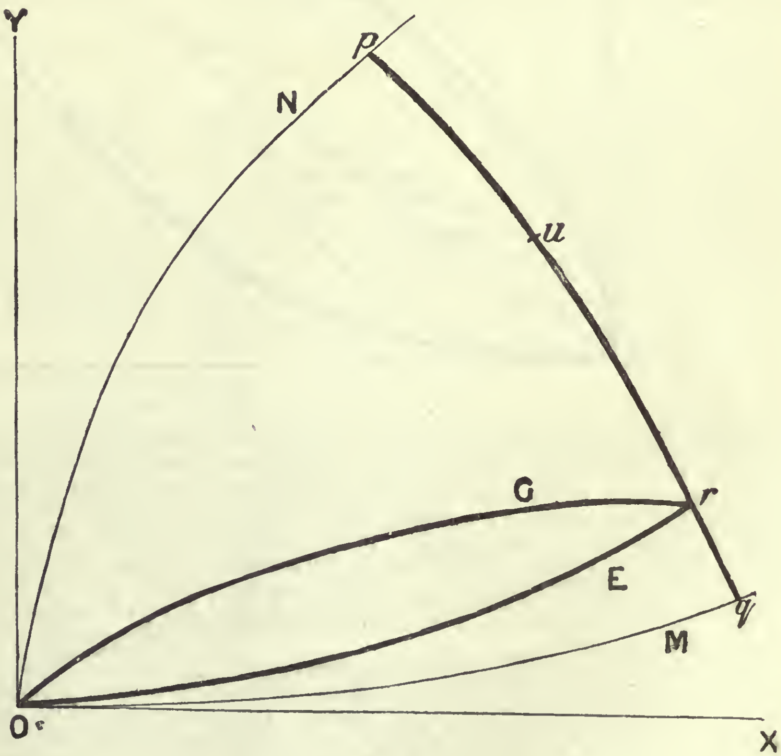


FIG. 9.

(*k*) ONE-SIDED MONOPOLY.—In Fig. 8 let the curve SS′ represent the demand of the public for a monopolized article, the abscissa denoting price, the ordinate quantity. Then, as Cournot shows, it is the interest of the monopolist that the rectangle $Oy_r rx$ should be a *maximum* ("Recherches," Art. 25), or rather the *greatest possible*. The solution is not likely to be indeterminate, except in the particular case where the demand-curve is an equilateral hyperbola (contrast Sidgwick, "Pol. Econ.," book ii. chap. ii. § 4).

(*l*) TWO-SIDED MONOPOLY.—In Fig. 9 let Op and Oq represent the curves of constant satisfaction, or indifference-curves [above, note (*d*); "Theorie der Preise," Appendix II.; "Mathematical Psychics," p. 21] drawn through O for two individuals or combinations respectively. Then the *locus* of bargains which it is not the interest of both parties to disturb is the *contract-curve, pq* ("Math. Psych.," *loc. cit.*). At what point, then, on this curve will the transaction settle down? If we assume that the conditions of a market are retained, the required point is at the intersection of the supply- and demand-curves, which is on the contract-curve. That is the solution of Messrs. Auspitz and Lieben ("Theorie," p. 381). It corresponds to the principle laid down by Prof. Marshall for the action of arbitrators (referred to above in note). But Prof. Menger, who has a numerical scheme equivalent to a rudimentary contract-curve ("Grundsätze," pp. 176–78), and Prof. Böhm-Bawerk, referring to the "*Spielraum*" afforded by the indeterminates of bargain, recommend to "split the difference." Instead of "equal," "*equitable*" division has been proposed by the present writer—namely, that adjustment which produces the maximum of utility to all concerned; not subject to the conditions of a market, but irrespectively thereof [equations (β) and (γ), without equation (α) in note (*e*) above], the utilitarian arrangement, which also is represented by a point in the contract-curve, say *u* in Fig. 9. Such might seem to be the ideally most desirable arrangement; but very likely the practically best, the πρακτόν ἀγαθόν, is in the neighbourhood indicated by Prof. Marshall and Messrs. Auspitz and Lieben.

(*m*) THE AUSTRIAN SCHOOL.—Prof. Menger and his followers have expressed the leading propositions of the economic calculus—the law of diminishing utility, the law of demand and supply, and so forth—by means of particular numerical examples, supplemented with copious verbal explanation. Their success is such as to confirm the opinion that the mathematical method is neither quite indispensable nor wholly useless, *nec nihil nec omnia*, like most scientific appliances. Conceding that in the main they impart a saving knowledge of the true theory of value, it may still be maintained that they occasionally emphasize the accidents of a particular example as if they formed the essence of the general rule; that their explanations are excessively lengthy; and yet their meaning sometimes is obscure. For instance, Prof. Böhm-Bawerk may seem to attach undue importance to his conception of the *Grenzpaar*. He illustrates the play of demand and supply by supposing a market in which on the one hand there are a number of dealers each with a horse to sell, and on the other hand a number of would-be buyers (*Konrad's Jahrbuch*, 1886; "Kapital," p. 211; cp. Mr. James Bonar's excellent article in the *Quarterly Journal of Economics*, 1888). The latter are arranged in the order of their strength: first, the one who is prepared to give most for a horse, the highest price which the second can afford is less, and so on. Parallel to this

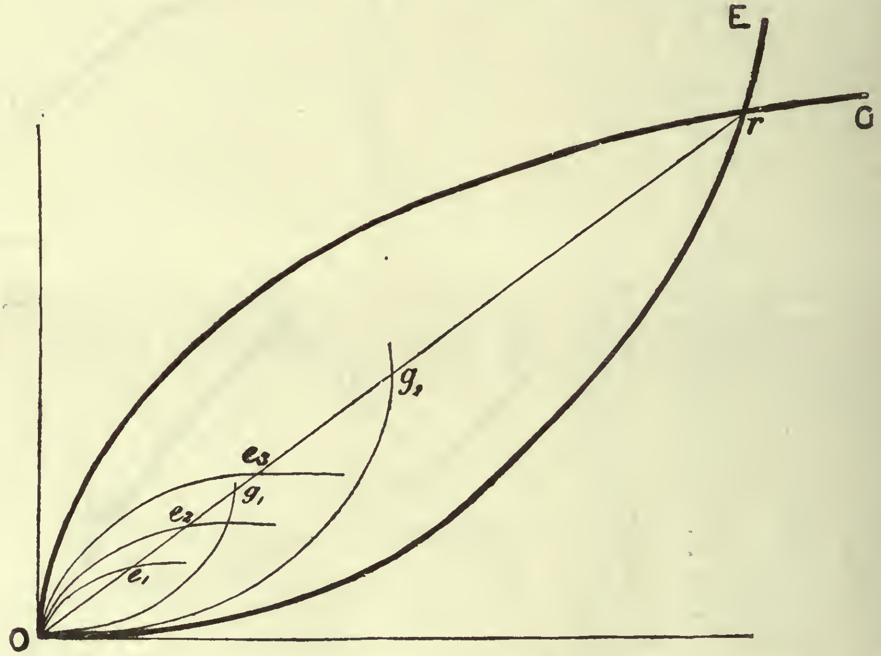


FIG. 10.

arrangement is that of the would-be sellers: first, he who can sell cheapest, and so on. Upon this hypothesis it might happen that the fifth would-be buyer is willing to give a little more than the lowest figure which the fifth would-be seller will take; while the sixth on the side of the buyers is not willing to give quite as much as the sixth horse-dealer stands out for. In this case five horses only will be sold; and the couple who are the last between whom a bargain is possible—buyer No. 5 and seller No. 5—enjoy a mighty distinction as the *Grenzpaar*; an honour which is to some extent shared with No. 6, the first couple between whom a bargain is impossible.

Now this attention to a particular couple is not always appropriate. How if the weakest actual buyer should prove to be, not buyer No. 5 but buyer No. 1, as to a *second* horse? Prof. Böhm-Bawerk, indeed, has thought of this case, and called attention to it in a note to his later redaction ("Kapital," p. 218). So far—although the whole simplicity of the scheme is destroyed when we permit second and third horses to the different buyers and sellers—the conception of a "limiting couple" may still be retained. It will be found, however, that this idea is not appropriate to the general case of a divisible commodity, which a single individual on one side of the market may buy from or sell to a large number on the other side. That general case is much more clearly represented by a diagram like Fig. 10, where the inner thin-lined curves represent the dispositions of the individual dealer, the outer thick curves the collective supply and demand (cp. Auspitz and Lieben, "Theorie der Preise"). No doubt Prof. Böhm-Bawerk's conception is appropriate to a particular case, that in which the *kleinste marktübliche Mengeneinheit*, in the phrase of Messrs. Auspitz and Lieben (*ibid.*, p. 123), is considerable. But it is better, with those eminent theorists, to begin with the general or, at least, the simple case.

As an instance of the excessive circumlocution in which the purely literary method is liable to be entangled, we may notice the doctrine of objective and subjective value, which occupies many pages in the works which we have cited. I have been unable to find more in the distinction than what is visible on a glance at the appropriate diagram. The individual's subjective estimate of worth is expressed by his particular demand- or supply-curve, Oe_1, Oe_2, &c., Og_1, Og_2, &c., in Fig. 10. The proper combination of those individual curves gives the collective demand- and supply-curves, of which the intersection represents the "objective" value.

Moreover, verbal circumlocutions are so little adapted to express mathematical conceptions that we are sometimes left in uncertainty as to our author's meaning. When Prof. Böhm-Bawerk remarks that there is something special in the labour-market, in that the buyer will vary his arrangements according to the price of the article, the rate of interest ("Kapital," p. 407), does he specify the property which Messrs. Auspitz and Lieben have stated as general—that the utility function [our ψ, note (*e*) above] is discontinuous, being different for large and small values of the variable under consideration?

These deficiencies are more conspicuous in other writings of the Austrian school. A glance at Fig. 10, an intuition of the corresponding algebraic formulæ, will show that the notion of an *average* imported into the doctrine of value by Dr. Emil Sax ("Staatswirthschaft") is not quite appropriate. As an instance in which great abridgment would be effected by mathematical expression, we might notice the last three chapters of Dr. Zuckerkandl's "Theorie der Preise." Again the difficulty of conveying technical propositions without the proper phraseology may be illustrated by Prof. Wieser's "Der natürliche Werth," when he speaks of value and final utility having place in a Communistic or Socialistic State (p. 26, note, and *passim*). May his meaning thus be formulated? In an economical *régime* distribution and exchange are regulated by the condition that the final utility of all concerned should be zero, the total utility a minimum, *subject to the law that there should be only one rate of exchange in a market.* In a communistic or utilitarian *régime* the limitation which the last italicized clause expresses is removed. In terms employed in our note (*e*) the economical adjustment is determined by the equations (α), (β), and (γ); the utilitarian adjustment is determined by (β) and (γ) only—in short, the distinction between the points *r* and *u* in our Fig. 9 referring to note (*e*).

In offering these too brief criticisms I regret that my limits impose a curtness which is hardly consistent with courtesy.

SECTION G.

MECHANICAL SCIENCE.

Opening Address by William Anderson, M.Inst.C.E., President of the Section.

I have had considerable difficulty in selecting a subject which should form the main feature of my address. This meeting being held in Newcastle, it seemed almost imperative that I should dwell upon two industries which may be said to have had their genesis here: that I should direct your attention to the extraordinary development of the system of transmitting power by hydraulic agency, and the use of the same agency for lifting enormous weights and exerting mighty pressures; and that I should not neglect to notice a manufacture of specially national importance—that of heavy artillery, and of ships of war sent forth fully equipped and ready to take their places in our first line of defence.

The desire which I felt of treating of these subjects was heightened by the opportunity which it would have afforded of paying a tribute of respect and admiration to the distinguished citizen of this town, who, by his genius and perseverance, created the Elswick Works, raised the character of British engineering, and rendered his country services so eminent that Her Majesty has seen fit to recognize them by bestowing honours higher than any which an engineer has hitherto been able to achieve.

But I felt that the themes mentioned, important as they are, have been frequently treated of by able men, and that I would perhaps render more service to Mechanical Science if I drew your attention to a subject which appears to me to be bearing with daily augmenting force on the practical manipulation of the materials used in construction. I allude to the molecular structure of matter. This branch of science has, up to the present time, been left very much in the hands of the chemist and the physicist, and I dare say that many engineers may think that it is by no means desirable to change the arrangement; but I hope to show that the progress of engineering, the more exact methods of dealing with the properties of materials, the increased demands on their powers of endurance, render it imperatively necessary that mechanics should interest themselves more deeply in their internal structures and the true meaning of the laws by which their properties are defined.

Five years ago, at Montreal, in his address to the Mathematical Section, Sir William Thomson took for his subject the ultimate constitution of matter, and discussed, in a most suggestive manner, the very structure of the ultimate atoms or molecules. He passed in review the theories extant on the subject, and pointed out the progress which had been made in recent years by the labours of Clausius, of Clerk Maxwell, of Tait, and of others, among whom his own name, I may add, stands in unrivalled prominence.

I will not presume to enter into the field of scientific thought and speculation traversed by Sir William Thomson, because I am only too conscious that both my mathematical knowledge and my acquaintance with the natural sciences is too limited to entitle the views which I may have formed to any respect; I propose to draw attention only to some general considerations, and to point out to what extent they practically interest the members of this Section.

In a lecture delivered at the Royal Institution last May, Prof. Mendeleeff attempted to show that there existed an analogy between the constitution of the stellar universe and that of matter as we know it on the surface of the earth, and that from the motions of the heavenly bodies down to the minutest interatomic movements in chemical reactions the third law of Newton held good, and that the application of that law afforded a means of explaining those chemical substitutions and isomerisms which are so characteristic, especially of organic chemistry.

Examined from a sufficient distance, the planetary system would appear as a concrete whole, endowed with invisible internal motions, travelling to a distant goal. Taken in detail, each member of the system may be involved in movements connected with its satellites, and again each planet and satellite is instinct with motions which, there is good reason to believe, extend to the ultimate atoms, and may even exist, as Sir W. Thomson has suggested, in the atoms themselves. The total result is complete equilibrium, and, in many cases, a seeming absence of all motion, which is, in reality, the consequence of dynamic equilibrium, and not the repose of immobility or inertness.

The movements of the members of the stellar universe are, many of them, visible to the eye, and their existence needs no demonstration; but the extension of the generalization just mentioned to substances lying, to all appearances, inert on the earth's surface is not so apparent. In the case of gases, indeed, it is almost self-evident that they are composed of particles, so minute as to be invisible, in a condition of great individual freedom. The rapid penetration of odours to great distances, the ready absorption of vapour and of other gases, and the phenomena connected with diffusion, compression, and expansion seem to demonstrate this. One gas will rapidly penetrate another and blend evenly with it, even if the specific gravities be very different. The particles of gases are, as compared with their own diameters, separated widely from each other; there is plenty of room for additional particles; hence any gas which would, by virtue of its molecular motion, soon diffuse itself uniformly through a vacuum will also diffuse itself through one or more other gases, and once so diffused, it will never separate again. A notable example of this is the permanence of the constitution of the atmosphere, which is a mere mixture of gases. The oxygen and the nitrogen, as determined by the examination of samples collected all over the world, maintain sensibly the same relative proportions, and even the carbonic acid, though liable to slight local accumulations, preserves, on the whole, a constant ratio; and yet the densities of these gases differ very greatly.

Liquids, though to a much less degree than gases, are also composed of particles separated to a considerable relative distance from each other, and capable of unlimited motion where no opposing force, such as gravity, interferes; for under such circumstances their energy of motion is not sufficient to overcome the downward attraction of the earth; hence they are constrained to maintain a level surface.

The occlusion of gases without sensible comparative increase of volume shows that the component particles are widely separated. Water, for example, at the freezing-point occludes above one and three-quarter times its own volume of carbonic oxide, and about 480 times its volume of hydrochloric acid, with an increase of volume, in the latter case, of only one-third; and sulphuric acid absorbs as much as 600 times its bulk of methylic ether. The quantity of gas occluded increases directly as the pressure, which seems to indicate that the particles of the occluded gas are as free in their movements among the particles of the liquid as they would be in an otherwise empty containing vessel.

Liquids, therefore, are porous bodies whose constituent particles have great freedom of motion. It is no wonder, consequently, that two dissimilar liquids, placed in contact with each other, should interpenetrate one another completely, if time enough be allowed; and this time, as might be expected, is considerably greater than that required for the blending of gases, because of the vastly greater mobility of the particles of the latter. The diffusion of liquids takes place not only when they are in actual contact, but even when they are separated by partitions of a porous nature, such as plaster of Paris, unglazed earthenware, vegetable or animal membranes, and colloidal substances, all of which may be perfectly water-tight in the ordinary sense of the term, but yet powerless to prevent the particles of liquids making their way through simultaneously in both directions.

The rate of diffusion increases with the temperature; but an increase of temperature, we know, is synonymous with increased molecular motion of the body, and with increased activity of this kind we would naturally look for more rapid interchanges of the moving atoms. Such phenomena are only conceivable on the supposition that active molecular motion is going on in an apparently still and inert mass.

When we come to solid substances the same phenomena appear.

The volumes of solids do not differ greatly from the volumes of the liquids from which they are congealed, and the solid volumes are generally greater. The volume of ice, for example, is one tenth greater than that of the water from which it separates. Solid cast-iron just floats on liquid iron, and most metals behave in the same way; consequently, if the liquids be porous the solids formed from them must be so also; hence, as might be expected, solids also occlude gases in a remarkable manner. Platinum will take up five and a half times its own volume of hydrogen, palladium nearly 700 times, copper 60 per cent., gold 29 per cent., silver 21 per cent. of hydrogen and 75 per cent. of oxygen, iron from eight to twelve and a half times its volume of a gaseous mixture chiefly composed of carbonic oxide.

Not only are gases occluded, but they are also transpired under favourable conditions of temperature and pressure, and even liquids can make their way through. Red-hot iron tubes will permit the passage of gases through their substance with great readiness, common coal-gas under high pressure transpires through the steel of the containing vessel, and it is well known that mercury will penetrate tin and other metals with great rapidity, completely altering their structure, their properties, and even their chemical compositions.

The evidence of the mobility of the atoms or molecules of solid bodies is overwhelming. Substances when reduced to powder, may, even at ordinary temperatures, be restored to the homogeneous solid condition by pressure only. Thus, Prof. W. Spring, some ten years ago, produced from the powdered nitrates of potassium and sodium, under a pressure of thirteen tons to the square inch, homogeneous transparent masses of slightly greater specific gravity than the original crystals, but not otherwise to be distinguished from them. More than that, from a mixture of copper filings and sulphur he produced, under a pressure of thirty-four tons per square inch, perfectly homogeneous cuprous sulphide, Cu_2S, the atoms of the two elements having been brought, by pressure, into so intimate a relation to each other that they were able to arrange themselves into molecules of definite proportion; and, still more remarkable, the carefully dried powders of potash, saltpetre, and acetate of soda were, by pressure, caused to exchange their metallic bases and form nitrate of soda and acetate of potash.

The same movements and changes have taken place, and are still going on, in Nature's laboratory. During the countless ages with which geology deals, and under the enormous pressures of superincumbent masses, stratified sedimentary rocks become crystallized and assume the appearance of rocks of igneous origin, and not only so, but rocks of whatever origin, crushed and ground to pieces by irresistible geological disturbances, reconstruct themselves into new forms by virtue of the still more irresistible and constant action of molecular forces and movements. Those who had the privilege of hearing Prof. A. Geikie's brilliant lecture at the Royal Institution last session will remember the striking series of microscopic slides which he exhibited, and by the aid of which he illustrated the changes of structure to which I have alluded.

At high temperatures the same effects are more easily produced on account of the greater energy of motion of the atoms or molecules. In the process of the manufacture of steel by cementation, or in case-hardening, the mere contact of iron with solid substances rich in carbon is sufficient to permit the latter to work its way into the heart of the former, while in the formation of malleable cast-iron the carbon makes its way out of the castings with equal facility; it is a complete case of diffusion of solid substances through each other, but, on account of the inferior and restricted mobility of the particles at ordinary temperatures, a higher degree of heat and longer time are needed than with liquids or gases.

Again, when, by the agency of heat, molecular motion is raised to a pitch at which incipient fluidity is obtained, the particles of two pieces brought into contact will interpenetrate or diffuse into each other, the two pieces will unite into a homogeneous whole, and we can thus grasp the full meaning of the operation known as "welding." By the ordinary coarse methods but few substances unite in this way, because the nature of the operation prevents, or at any rate hinders, the actual contact of the two substances; but when molecular motion is excited to the proper degree by a current of electricity, the faces to be joined can be brought into actual contact, the presence of foreign substances can be excluded, and many metals not hitherto considered weldable, such as tool steel, copper, and aluminium are readily welded, as many of us witnessed at the hands of Prof. Ayrton in the highly instructive lecture on electricity delivered last year at our Bath meeting. Again, a mere superficial union of different metals takes place readily under the influence of high temperature and moderate pressure, as we see in the operations of tinning, soldering, and brazing. The surfaces of the metals must be made as clean as possible; the solder, which melts at a lower temperature than the metal to be soldered or brazed, is applied, and at a comparatively moderate temperature and under very slight pressure the particles interpenetrate each other; the two metals unite and form an alloy, by the intervention of which the two surfaces are joined. This effect is very well illustrated by the action which takes place at the surface of contact of two dissimilar liquids. If brine, for example, be placed in the lower part of a glass tube, and ordinary water, coloured in some way, be carefully poured on the top, a sharp plane of demarcation will appear, but in a short time the plane of separation will become blurred, and will ultimately disappear, a local blending of the two waters will take place, and will thus present a case of fluid-welding.

It seems plain, therefore, that apparently inert solid masses are also built up of moving particles in dynamic equilibrium, for without such an assumption it would be hard to explain the phenomena to which I have alluded. But in addition to this evidence we can adduce the effects of other forms of energy, which we recognize under the names of radiant heat, light, and electricity. These we know to be forms of motion which can be communicated and converted from one to the other, from the invisible to the visible. The movement which we term radiant heat, acting through the instrumentality of the luminiferous ether which is believed, on the strongest grounds, to pervade all space and all matter, is competent to augment the quantity of movement in the particles of substances, and generally to cause an enlargement of volume. Conversely, when the particles, by contact or by radiation, part with their heat, either to surrounding objects or to space, the quantity of motion is reduced, the body contracts, and this contraction goes on down to temperatures far below those at which we have to work in practice, and consequently at all ordinary temperatures there must be abundant room for molecular motion.

Again, energy in the form of light operates changes in the surface of bodies, causing colours to fade, and giving to photography the marvellous power which it possesses. Light decomposes the carbonic acid of the atmosphere in the chlorophyll of green leaves, and determines chemical combinations, such as chlorine with hydrogen to form hydrochloric acid, or carbonic oxide with chlorine to form chlorocarbonic acid. It is inconceivable that these effects could be produced unless the undulations of light were competent to modify the molecular motions already existing in the solid liquid and gaseous bodies affected.

Electricity exerts a similar influence. Generated by the molecular movements caused by chemical activity, whether directly, as in the primary battery, or indirectly, as in the dynamo, it is competent to increase the molecular movements in bodies so as to produce the effects of heat directly applied; it is capable of setting up motions of such intensity as to produce chemical changes and decompositions, to say nothing of the whole series of phenomena connected with magnetism, with induction, or the action through space and through non-conducting bodies, which, as in the case of radiant heat and light, seems to imply the existence of an interatomic ether. Conversely, changes of molecular equilibrium, brought about by the action of external forces, produce corresponding changes in electrical currents: witness the effects of heat, for example, on conductivity and the wondrous revelations of molecular change obtained by the aid of Prof. Hughes' induction balance. The behaviour of explosives illustrates also, and in a striking manner, the effects of disturbing molecular equilibrium. An explosive is a substance which contains in itself, in a solid or liquid form, all the elements necessary to produce a chemical change by which it is converted into the gaseous state. The application of heat, of pressure, or of impact, causes, as in Prof Spring's experiments, chemical union to take place, first at the spot where the equilibrium is disturbed by the application of external force, and afterwards, with great rapidity, throughout the mass, the disturbance being propagated either by the air surrounding the particles or by the luminiferous ether with all the rapidity of light; the chemical reaction is accelerated by the pressure which may arise, for example, if the explosive be confined in the chamber of a gun or in the borehole of a blast. High explosives, as they are termed, are comparatively inert to ordinary ignition; but when the molecular equilibrium is suddenly disarranged throughout the mass by the detonation of a percussion fuse, combination takes place instantly throughout, and violent explosion follows. In a similar manner some gases, such as acetylene, cyanogen, and others, can be decomposed by detonation and reduced to their solid constituents. Prof. Thorpe has devised a very beautiful lecture experiment, in which carbon disulphide is caused to fall asunder into carbon and sulphur by the detonation of fulminate of mercury fired by an electric spark. In these cases a reverse action takes place, but illustrates equally well the conversion of one form of energy into others, and the consequent disturbance of molecular equilibrium in the substances affected. It seems to me clear, therefore, that the time has come when the conception of dynamic equilibrium in the ultimate particles of matter in all its forms must take the place of the structural system of inert particles. I cannot conceive how the phenomena which I have enumerated can be explained on the supposition that matter is built up of motionless particles—how, for example, a stack of red and yellow bricks could ever change the order of arrangement without being completely pulled asunder and built up again, in which case an intermediate state of chaos would exist; but I can easily comprehend how a dense crowd of people may appear as a compact mass, streaming, it may be, in a definite direction, and yet how each member of that mass is endowed with limited motion, by virtue of which he may push his way through without disturbing the general appearance; how the junction of two crowds would form one whole, though, perchance, altered in character; and how even Prof. Spring's experiments may be explained by the supposition that bystanders on the edge of a crowd would be forced, by external pressure, to form part of it and partake of its general movements.

It is a suggestive fact that the product of the atomic weight of certain groups of substances and their specific heats is a constant quantity which, for the greater number of the elements, does not differ much from 6·5. This implies that the quantity of heat necessary to raise the temperature of the atoms of any one of the groups to any given extent is the same; hence these atoms will be endowed with the same amount of energy at any given temperature, and therefore would be competent to replace each other without disturbing the general dynamic equilibrium.

When it is conceded that molecular motion pervades matter in all its forms, and that the solid passes, often insensibly, into the fluid, or even direct into the gaseous, it follows, almost of necessity, that there must be a border-land, the limits of which are determined by temperature and pressure, in which substances are constantly changing from one state to another. This is observable in fusion, but to a more marked degree in evaporation, where the particles are being incessantly launched into space as gas and return as constantly to the liquid state. Henri Ste. Claire Deville has investigated similar phenomena in chemical reactions; he has found that at certain temperatures and pressures substances fall asunder and combine much in the way in which evaporation takes place, and has given the name of "dissociation" to this property of matter Prof. Mendeleeff and others have extended the great French chemist's observations, and have formulated the general law that substances are capable of dissociation at all temperatures, not only in the case of chemical unions, but also in that of solutions.

If steel be looked upon as a solution of carbon and iron, then the hardening of steel is explained by the theory that dissociation has taken place at the temperature at which it is suddenly cooled, the sudden cooling fixing the molecular motion at such an amplitude or phase that it gives a characteristic structure, one of the properties of which is extreme hardness. In tempering, the gradual communication of heat causes dissociation again to take place, the molecular equilibrium is modified by the increased energy imparted to the particles, and when suddenly cooled at any point there remains again a distinct substance, composed of iron and carbon, partly in various degrees of solution and partly free, and again possessing special mechanical qualities. That steel, and probably other alloys, differ in the nature of their composition according to the way in which they are worked, both with respect to heat and mechanical pressure, has been abundantly proved by many eminent metallurgists, and especially by Sir Frederick Abel, in the extended researches which he has recently carried out, on the hardening of steel, for the Institution of Mechanical Engineers, and it would appear as a natural sequence that the properties of steel would be greatly affected by the manner in which its temperature was changed, as we indeed find that it is when these changes are produced by baths of melted metals, by oil, or by water at different temperatures. The action which takes place may be illustrated by what would happen supposing that a complicated dance, such as the lancers, were suddenly stopped in various phases of the figures. The component parts would always remain the same, but the relative distribution of the partners would vary continually, and analysis would show that at one time each gentleman was associated with a particular lady; at another, that two ladies were attached to a single gentleman, while a number of gentlemen had no partners at all; and yet again, at another, that the movements which were once rectilinear have become circular. In each case the groups would assume a totally distinct appearance.

In support of these views it may be stated that, as far as I know, no pure element is capable of being hardened or tempered, the reason being that no chemical change can take place when there is only one substance; the effect of heat or pressure, however suddenly applied, produces merely a change of form which does not appear to carry with it any corresponding alteration of mechanical properties.

It may be urged, however, that it is unlikely that alloys or solutions could be affected in a manner so marked merely by small changes at comparatively low temperatures; but I would observe that "great and little" are relative terms, and we have abundant evidence of the immense effects produced by what would be called "little" causes. Sir Frederick Bramwell, in his address last year, drew attention to the importance of the "next to nothing." It is not so very long ago that anyone would have been considered a dreamer for propounding a theory that the presence of the fraction of a per cent. of carbon, phosphorus, or sulphur would totally alter the character of iron; it is known that the addition of one two-thousandth part of aluminium to molten iron makes the pasty ma s as fluid as water; that the presence of the smallest impurity in copper has a disastrous effect on its powers of conducting electricity; and that the addition of one-thousandth part of antimony converts the "best selected" copper into the worst conceivable. I need hardly allude to the great part played in Nature by microscopic organisms, and how much of the beauty of our seas and rivers is derived from substances so minute that nothing but the electric beam of Prof. Tyndall is capable of revealing their presence.

There is one more circumstance connected with my subject to which I must draw your attention, because, though its application to the mechanical properties of substances is very recent, it promises to be of great importance. I allude to the periodic law of Dr. Mendeleeff. According to that law, the elements, arranged in the order of their atomic weights, exhibit an evident periodicity of properties, and, as Prof. Carnelley has observed, the properties of the compounds of the elements are a periodic function of the atomic weights of their constituent elements. Acting on these views, Prof. Roberts-Austen has recently devoted much time and labour to testing their exactness with reference to the mechanical properties of metals. The investigation is surrounded by extraordinary difficulties, because one of the essential features of the inquiry is that the metals operated on should be absolutely pure. For chemical researches a few grains of a substance are all that is needed, and the requisite purity can be obtained at a moderate cost of time and labour; but when mechanical properties have to be determined considerable masses are needed, and the funds necessary for obtaining these are beyond the reach of most private individuals. I cannot help suggesting that wealthy institutions, such as many of those connected with our profession, could not employ their resources more wisely than in giving the means of following up the researches which Prof. Roberts-Austen has inaugurated.

In view of the difficulty of obtaining metals of sufficient purity, he selected gold as his base, because that metal can be more readily brought to a state of purity than any other, and is not liable to oxidation. In a communication to the Royal Society, made last year, he shows that the metals alloyed with gold which diminish its tenacity and extensibility have high atomic volumes, while those which increase these properties have either the same atomic volumes as gold or have lower ones. The inquiry has only just been commenced, but it appears to me to promise results which, to the engineer, will prove as important and as fruitful of progress as the great generalization of Mendeleeff has been to chemists. A law which can not only indicate the existence of unknown elements but which can also define their properties before they are discovered, if capable of application to metallurgy, must surely yield most valuable results, and will make the compounding of alloys a scientific process instead of the lawless and haphazard operation which it is now.

The practical importance of the views I have enunciated are, I think, sufficiently obvious. Everyone will admit that an external force cannot be applied to a system in motion without affecting that motion; consequently matter, in whatever state, cannot be touched without changes taking place, which will be more or less permanent. The application of heat will cause a change of volume, and, at last, a change of condition; the application of external stresses will also produce a change of volume; and it is natural to infer that there must be some relation between the two, and, accordingly, Prof. Carnelley has drawn attention to the fact that the most tenacious metals have high melting-points, though here again there is a great want of exactness, partly on account of the difficulty of measuring high temperatures, and partly by reason of the scarcity of pure materials.

Again, long-continued stresses, or stresses frequently applied, may be expected to produce permanent changes of form, and so we arrive at what is termed the fatigue of substances. Stretched beyond their elastic limits, which limits I do not suppose to exist except when stresses are applied quickly, substances are permanently deformed, and the same effects follow the long application of heat. The constant recurrence of stresses, even of those within the elastic limit, causes changes in the arrangement of the molecules of substances which slowly alter the properties of the latter, and in this way pieces of machinery, which theoretically were abundantly strong for the work they had to perform, have failed after a more or less extended period of use. The effect is intensified if the stresses are applied suddenly, if they reach nearly to the elastic limit, and if they are imposed in two or more directions at once, for then the molecular disturbance becomes very intense, the internal equilibrium is upset, and a tendency to rupture follows. Such cases occur in artillery, in armour-plates, in the parts of machinery subject to impact; and, as might be expected, the destructive effects do not always appear at once, but often after long periods of time.

When considerable masses of metal have to be manipulated by forging or by pressure in a heated condition, the subsequent cooling of the mass imposes restrictions on the free movement of some, if not all, of the particles; internal stresses are developed which slowly assert themselves, and often cause unexpected failures. In the manufacture of dies for coining purposes, of chilled rollers, of shot and shell hardened in an unequal manner, spontaneous fractures take place without any apparent cause, and often after long delay, the reason being that the constrained molecular motion of the inner particles gradually extends the motion of the outer ones until a solution of continuity is caused.

Similar stresses occur in such masses as crank shafts, screw shafts, gun hoops, &c. The late General Kalakoutsky, some seventeen years ago, commenced a systematic investigation into the internal stresses in the tubes and hoops of guns and in armour-piercing shells. The method he pursued was to cut disks or rings about half an inch thick off the hoops and shells, to divide the metal of each disk into from four to six rings, to fix by means of silver plugs, on which very finely marked cross-lines were drawn, from four to eight points on the surface of each ring, and then to measure, with extreme exactness, the changes in diameter produced in every ring by the successive cutting out of the rings. Knowing by direct tests the mechanical properties of his material, he was able, from the changes in the diameters, to calculate what the tangential stresses in every part of each disk were, and to draw inferences as to their fitness for the work they were intended to perform. The same method of investigation has been pursued by Captain Noble of the Elswick Works, and by Lieutenant Crozier of the United States Artillery, with the practical result that probably much more attention will be paid in future to the principles on which the annealing and hardening of steel is carried on. A gun hoop or tube, to be in the best condition to resist a bursting stress, should have its inner surface in a state of compression, and its outer in a state of tension, and the hoops should be shrunk on to the tubes or on to each other with but very little pressure. General Kalakoutsky proposed, in order to set up beneficial internal stresses, that tubes which were being annealed should be cooled from the inside by a jet of steam, of air, of water, or of oil; and he advocated the practice of testing the effects of each new method of manufacture or of treatment by the careful measurements of slices of the finished material instead of working at random, as is still very much the practice. It is evident, also, that a sample of steel cut out of a gun hoop or crank shaft, and tested, can afford no indication of the available tenacity of the same sample *in situ*. When released from the constraint of its surroundings, the particles must, of necessity, change their condition, for the disturbing forces have been removed; and the probability is that, if the steel be good, the test will prove satisfactory, especially if some time be allowed to elapse between cutting out the sample and testing it, and a false security will be engendered such as has often led to disastrous results.

The influence of time on steel seems to be well established: the highest qualities of tool steel are kept in stock for a considerable period; and it seems certain that bayonets, swords, and guns are liable to changes which may account for some of the unsatisfactory results which have manifested themselves at tests repeated after a considerable interval of time. As all these things have been hardened and tempered, there must necessarily have been considerable constraint put upon the freedom of motion of the particles, this constraint has gradually been overcome, but at the expense of the particular quality of the steel which it was originally intended to secure.

I have now laid before you the views respecting the constitution of matter which I think are gaining ground, which explain many phenomena with which we are familiar, and which will serve as guides in our treatment of metals, and especially of alloys; but I must admit that the subject is still by no means clear, that a great deal more definition is wanted, and that we are still awaiting the advent of the man who shall do for molecular physics what Newton did for astronomy in explaining the structure of the universe.

One of the most remarkable features of the last thirty years is the introduction of petroleum, and the wonderful development to which the trade in it has attained.

Under the generic name of petroleum are embraced a vast variety of combinations of carbon and hydrogen, each of which is distinguished by some special property. At ordinary temperatures and pressures some are gaseous, some are liquid, and some solid, and most are capable of being modified by suitable treatment under various temperatures and pressures. The employment of petroleum in the arts is still extending rapidly. Used originally for illuminating purposes, it is now employed as fuel for heating furnaces and steam-boilers; as a working agent in heat-engines; valuable medicinal properties have been discovered; and as a lubricant it stands unrivalled.

As an illuminant, even in this country, it is, to a large extent, superseding every other in private houses, and even in public lamps, because it gives a cheaper and more brilliant light than ordinary gas, and leaves the consumer free from the tyranny of great and privileged companies.

As fuel it is especially convenient, cleanly, and economical. Stored in tanks of suitable construction, it is sprayed into the furnace without labour and without creating dust and dirt; it is especially convenient in locomotive and marine work on account of the rapidity, ease, and cleanliness with which it can be run into the tender or into the oil-bunkers of a ship. As a working agent in heat-engines it is employed in two ways. First as vapour, generated from the liquid petroleum contained in a boiler, very much in the same way as the vapour of water is used in an engine with surface condenser, the fuel for producing the vapour being also petroleum. Very signal success has been obtained by Mr. Yarrow and others in this mode of using mineral oil, especially for marine purposes and for engines of small power; there seems to be no doubt that by using a highly volatile spirit in the boiler a given amount of fuel will produce double the power obtainable by other means. and at the same time the machinery will be lighter and will occupy less space than if steam were the agent used. The other method is to inject a very fine spray of hot oil, associated with the proper quantity of air, into the cylinder of an ordinary gas-engine, and ignite it there by means of an electric spark or other suitable means. Attempts to use oil in this way date back many years, but it was not till 1888 that Messrs. Priestman Brothers exhibited at the Nottingham Show of the Royal Agricultural Society an engine which worked successfully with oil, the flashing-point of which was higher than 75° F., and was therefore within the category of safe oils. The engine exhibited was very like an ordinary Otto gas-engine, and worked in exactly the same cycle. A pump at the side of the engine forced air into a small receiver at a few pounds' pressure to the square inch. The compressed air, acting by means of a small injector, carried with it the oil in the form of fine spray, which issued into a jacketed chamber heated by the exhaust, in which the oil was vaporized. The mingled air and oil was thus raised to a temperature of about 300°, and was then drawn, with more air, into the cylinder, where, after being compressed by the return stroke of the piston, it was exploded by an electric spark, and at the end of the cycle the products of combustion were discharged into the air after encircling the spray chamber and parting with most of their heat to the injected oil. The results of careful experiments made by Sir William Thomson and by myself on different occasions were, that 1·73 pound of petroleum was consumed per brake-horse power per hour; but the combustion was by no means perfect, for a sheet of paper held over the exhaust-pipe was soon thickly spattered with spots of oil.

At the Windsor Show of the Royal Agricultural Society this year, Messrs. Priestman again exhibited improved forms of their engine; the consumption of oil fell to 1·25 pound per brake-horse power per hour, and a sheet of paper held over the exhaust remained perfectly clean. They also showed a portable engine of very compact construction, and quite adapted to agricultural use; the ordinary water cart, which has, in any case, to attend a portable steam-engine, being adapted to supply the water necessary to keep the working cylinder of the engine cool.

It is hardly necessary to state that the use of petroleum for furnace purposes of all kinds is increasing very rapidly, and the demand has naturally reacted on the supply in promoting improved means of transport; and Newcastle, again, has led the van in this matter, for Sir William Armstrong, Mitchell, and Co., Messrs. Palmer, and others have sent out a fleet of steamers constructed to carry the oil in bulk with perfect safety, both as regards the stowage of a cargo so eminently shifting, and with respect to risk from fire and from explosion.

The enormous consumption of petroleum and of natural gases frequently raises the question as to the probability of the proximate exhaustion of the supply; and, without doubt, many fear to adopt the use of oil, from a feeling that if such use once becomes general the demand will exceed the production, the price will rise indefinitely, and old methods of illumination, and old forms of fuel, will have to be reverted to From this point of view it is most interesting to inquire what are the probabilities of a continuous supply; and such an investigation leads at once to the question, "What is the origin of petroleum?" In the year 1877, Prof. Mendeleeff undertook to answer this question; and as his theory appears to be very little known, and has never been fully set forth in the English language, I trust you will forgive me for laying a matter so interesting before you. Dr. Mendeleeff commences his essay by the statement that most persons assume, without any special reason—excepting, perhaps, its chemical composition—that naphtha, like coal, has a vegetable origin. He combats this hypothesis, and points out, in the first place, that naphtha must have been formed in the depths of the earth. It could not have been produced on the surface, because it would have evaporated; nor over a sea bottom, because it would have floated up and been dissipated by the same means. In the next place, he shows that naphtha must have been formed beneath the very site on which it is found; that it cannot have come from a distance, like so many other geological deposits, and for the reasons given above—namely, that it could not be water-borne, and could not have flowed along the surface, while in the superficial sands in which it is generally found no one has ever discovered the presence of organized matter in sufficiently large masses to have served as a source for the enormous quantity of oil and gas yielded in some districts; and hence it is most probable that naphtha has risen from much greater depths under the influence of its own gaseous pressure, or floated up upon the surface of water, with which it is so frequently associated.

The oil-bearing strata in Europe belong chiefly to the Tertiary or later geological epochs; so that it is conceivable that in these strata, or in those immediately below them, carboniferous deposits may exist and may be the sources of the oil; but in America and in Canada the oil-bearing sands are found in the Devonian and Silurian formations, which are either destitute of organic remains, or contain them in insignificant quantities. Yet if the immense masses of hydrocarbons have been produced by chemical changes in carboniferous beds, equally large masses of solid carboniferous remains must still exist; but of this there is absolutely no evidence, while cases occur in Pennsylvania where oil is obtained from the Devonian rocks underlying compact clay beds, on which rest coal-bearing strata. Had the oil been derived from the coal, it certainly would not have made its way downwards; much less would it have penetrated an impermeable stratum of clay. The conclusion arrived at is, that it is impossible to ascribe the formation of naphtha to chemical changes produced by heat and pressure in ancient organized remains.

One of the first indices to the solution of the question lies in the situation of the oil-bearing regions. They always occur in the neighbourhood of, and run parallel to, mountain ranges,—as, for example, in Pennsylvania, along the Alleghanies; in Russia, along the Caucasus. The crests of the ranges, formed originally of horizontal strata which had been forced up by internal pressure, must have been cracked and dislocated, the fissures widening outwards, while similar cracks must have been formed at the bases of the ranges; but the fissures would widen downwards, and would form channels and cavities into which naphtha, formed in the depths to which the fissures descended, would rise and manifest itself, especially in localities where the surface had been sufficiently lowered by denudation or otherwise.

It is in the lowest depths of these fissures that we must seek the laboratories in which the oil is formed; and once produced, it must inevitably rise to the surface, whether forced up by its own pent-up gases or vapours, or floated up by associated water. In some instances the oil penetrating or soaking through the surface layers loses its more volatile constituents by evaporation, and, in consequence, deposits of pitch, of carboniferous shales, and asphalte take place; in other cases, the oil, impregnating sands at a lower level, is often found under great pressure, and associated with forms of itself in a permanently gaseous state. This oil may be distributed widely according to the nature of the formations or the disturbances to which they have been subjected; but the presence of petroleum is not in any way connected with the geological age of the oil-bearing strata: it is simply the result of physical condition and of surface structure.

According to the views of Laplace, the planetary system has been formed from incandescent matter torn from the solar equatorial regions. In the first instance this matter formed a ring analogous to those which we now see surrounding Saturn, and consisted of all kinds of substances at a high temperature, and from this mass a sphere of vapours, of larger diameter than the earth now has, was gradually separated. The various vapours and gases which, diffused through each other, formed at first an atmosphere round an imaginary centre, gradually assumed the form of a liquid globe, and exerted pressures incomparably higher than those which we experience now at the base of our present atmosphere. According to Dalton's laws, gases, when diffused through each other, behave as if they were separate; hence the lighter gases would preponderate in the outer regions of the vaporous globe, while the heavier ones would accumulate to a larger extent at the central portion, and at the same time the gases circulating from the centre to the circumference would expand, perform work, would cool in consequence, and at some period would assume the liquid or even the solid state, just as we find the vapour of water diffused through our present atmosphere does now. That which is true of changes of physical condition, Henri Ste. Claire Deville, in his brilliant theory of dissociation, has shown to be equally true with respect to chemical changes; and the cooling of the vapours forming the earth while in its gaseous condition was necessarily accompanied by chemical combinations, which took place chiefly on the outer surface, where oxides of the metals were formed; and as these are generally less volatile than the metals themselves, they were precipitated on to what there then was of liquid or solid of the earth, in the form of metallic rain or snow, and were again probably decomposed, in part at least, to their vaporous condition. The necessary consequence of this action is that the inner regions of the earth must consist of substances the vapours of which have high specific densities and high molecular weights—that is to say, composed of elements having high atomic weights—and that the heavier elementary substances would collect nearer the centre, while the lighter ones would be found nearer the surface. Our knowledge of the earth's crust extends but to an insignificant distance; yet, as far as we do know it, we find that the arrangement above indicated prevails. Hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, aluminium, silicon, phosphorus, sulphur, chlorine, potassium, calcium—substances whose atomic weights range from 1 to 40—became condensed, entered into every conceivable combination with each other, and produced substances the specific gravity of which averages about $2\frac{1}{2}$, never exceeds 4, and are found near the immediate surface of the globe.

But the mean specific gravity of the earth, as determined by Maskelyne, Cavendish, and others, certainly exceeds 5, and consequently the inner portion of our globe must be composed of substances heavier than those existing on the surface, and such substances are only to be found among the elements with high atomic weights. The question arises, What elements of this character are we likely to find in the depths of the earth? In the first place, since gases diffuse through each other, a certain proportion of the elements of high atomic weight will also be found on the surface of the earth. Secondly, the elements forming the bulk of the earth must be found in the atmosphere of the sun—if, indeed, the earth once formed part of its atmosphere; and of all the elements, iron, with a specific gravity exceeding 7, and with an atomic weight of 56, corresponds best with these requirements, for it is found in abundance on the surface of the earth; and the spectroscope has revealed the very marked presence of iron in the sun, where it must be partly in the fluid and partly in the gaseous state; and consequently iron in large masses must exist in the earth; so that the mean specific gravity of our planet may well be 5, the value which has been determined by independent means.

It is not easy, however, to define in what condition the mass of iron which must exist in the heart of the earth is likely to be. Iron is capable of forming a vast number of combinations, depending upon the relative proportion of the various elements present. Thus, in the blast-furnace, oxygen, carbon, nitrogen, calcium, silicon, and iron are associated, and produce, under the action of heat, besides various gases, a carburet of iron and slag, the latter containing chiefly silicon, calcium, and oxygen—that is to say, substances similar to those which form the bulk of the surface of the earth. But these same elements, if there be an excess of oxygen, will not yield any carburet of iron; and the same result will follow if there be a deficiency of silicon and calcium, because of the large proportion of oxygen which they appropriate. In the same way, during the cooling of the earth, if oxygen, carbon, and iron were associated, and if the carbon were in excess of the oxygen, the greater part of the carbon would escape in the gaseous state, while the remaining part would unite with the iron. It is certain that, in the heart of the earth, there must have been a deficiency of oxygen, because of its low specific gravity; and the argument is supported by the fact that free oxygen and its compounds with the lighter elements abound on the surface. Further, it must be presumed that much of the iron existing at great depths must be covered over and protected from oxygen by a coating of slag; so that, taking all these considerations into account, it is reasonable to conclude that deep down in the earth there exist large masses of iron in part at least in the metallic state or combined with carbon.

The above views receive considerable confirmation from the composition of meteoric matter, for it also forms a portion of the solar system, and originated, like the earth, from out of the solar atmosphere. Meteorites are most probably fragments of planets, and a large proportion of them include iron in their composition, often as carbides, in the same form as ordinary cast-iron—that is to say, a part of the carbon is free and a part is in chemical union with the iron. It has been shown, besides, that all basalts contain iron, and basalts are nothing more than lavas forced by volcanic eruptions from the heart of the earth to its surface. The same causes may have led to the existence of combinations of carbon with other metals.

The process of the formation of petroleum seems to be the following:—It is generally admitted that the crust of the earth is very thin in comparison with the diameter of the latter, and that this crust incloses soft or fluid substances, among which the carbides of iron and of other metals find a place. When, in consequence of cooling or some other cause, a fissure takes place through which a mountain range is protruded, the crust of the earth is bent, fissures are formed; or, at any rate, the continuity of the rocky layers is disturbed, and they are rendered more or less porous, so that surface waters are able to make their way deep into the bowels of the earth, and to reach occasionally the heated deposits of metallic carbides, which may exist either in a separated condition or blended with other matter. Under such circumstances it is easy to see what must take place. Iron, or whatever other metal may be present, forms an oxide with the oxygen of the water; hydrogen is either set free, or combines with the carbon which was associated with the metal, and becomes a volatile substance—that is, naphtha. The water which had penetrated down to the incandescent mass is changed into steam, a portion of which finds its way through the porous substances with which the fissures are filled, and carries with it the vapours of the newly formed hydrocarbons, and this mixture of vapours is condensed wholly or in part as soon as it reaches the cooler strata. The chemical composition of the hydrocarbons produced will depend upon the conditions of temperature and pressure under which they are formed. It is obvious that these may vary between very wide limits, and hence it is that mineral oils, mineral pitch, ozokerit, and similar products, differ so greatly from each other in the relative proportions of hydrogen and carbon. I may mention that artificial petroleum has been frequently prepared by a process analogous to that described above.

Such is the theory of the distinguished philosopher, who has framed it, not alone upon his wide chemical knowledge, but also upon the practical experience derived from visiting officially the principal oil-producing districts of Europe and America, from discussing the subject with able men deeply interested in the oil industry, and of collecting all the available literature on the subject. It is needless to remark that Dr. Mendeleeff's views are not shared by every competent authority; nevertheless the remarkable permanence of oil-wells, the apparently inexhaustible evolution of hydrocarbon gases in certain regions, almost force one to believe that the hydrocarbon products must be forming as fast as they are consumed, that there is little danger of th demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greate depths to be reached; and it should be remembered that, apar from the cost of sinking a deep well, there is no extra expens in working at great depths, because the oil generally rises to th surface or near it. The extraordinary pressures, amounting t 300 pounds per square inch, which have been measured in som wells seem to me to yield conclusive evidence of the impermea bility of the strata from under which the oil has been forced up and tend to confirm the view that it must have been forme in regions far below any which could have contained organi remains.

The weights and measures in use in this country are a sourc of considerable trouble and confusion. Besides the imperi measures, which are complicated enough, a great number local units are in use, so that unwary strangers are not unfre quently deceived, or, at any rate, if they hope to escape fro mistakes, have to apply themselves to the study of local custom In the scientific world, again, the metric system is now almo exclusively used, and the same may be said of engineers an manufacturers who have to do with foreign countries in whic French measures are in vogue. The same difficulty surroun the measurement of the power of motors. The unit of power indeed, from the nature of the case, common to the who world—it is unit of weight multiplied by unit of height—and with us the foot-pound, or 33,000 times the foot-pound, is generally accepted; but the difficulty lies in determining how the measure is to be applied. Thus, in the case of a water-motor, should the power be calculated by the energy latent in the falling water, or in the actual work given off by the motor? In heat-engines we have to deal with many variables. There is the initial pressure of the working agent, the terminal pressure, the length of stroke, the number of revolutions per minute, the indicated power in the cylinder, the effective power given off, and the adequacy of the means of supplying the working agent. In the early days of steam, when pressures were pretty uniform, and speed bore a certain relation to the stroke, the diameter of a cylinder was a tolerably close index to the power of the engine, and such simple rules as "10 circular inches to the horse-power," which prevailed among agricultural engineers, were tolerably intelligible. But in these days, when pressures, speeds, and rates of expansion vary so greatly, the size of the cylinder, or cylinders, is no longer a guide, and I imagine that most manufacturers have ceased to class their engines by their nominal horse-power. The problem is pretty simple in the case of pumping-engines, for there the nominal power may be taken, as it is in Holland, to be the actual work performed upon the water, and perhaps a similar rule might apply to motors driving dynamos, but for most other purposes no simple law is possible. In my own practice I have, for many years, been in the habit of classing engines by their indicated horse-power per one revolution for every probable initial pressure, below the maximum one for which the engines were designed, and for various rates of expansion. To facilitate the calculations I use curves which give the theoretical horse-power, on the supposition that steam expands according to Boyle's law, for 10,000 cubic inches of steam measured at the moment of exhaust, which is, in fact, the volume of the cylinder in single-cylinder engines, and the volume of the last cylinder in compounds. These curves are calculated for initial pressures rising by 25 pounds, and, in non-condensing engines, for the extreme range of expansion possible, and to fourteen expansions in condensing engines. The true indicated horse-power ranges from 80 per cent. to 85 per cent. of the theoretical, as above stated, the precise percentage depending upon the construction of the engine. As large engines are now almost always compound, the size of the cylinders is no guide to the lay mind; hence, in answering inquiries, it is necessary by some means to get at the actual horse-power expected and to settle the initial pressure, for on this point there is still much timidity among steam-users, so that the engine-builder has to adapt himself in this and other particulars to the needs or prejudices of his customer.

In marine engines, again, the difficulty is still greater, because the only measure of the effective power of the engines is the speed of the ship under given conditions of immersion. But the resistance of ships is a complicated matter, not perfectly ascertained yet, so that the speed attained in any new combination of engines and hull is by no means a certainty; hence some recognized measure of the power of a marine engine, depending only on the measurement of the cylinders and boilers, becomes very desirable.

So strongly has the want of a standard horse-power been felt by shipbuilders and marine engine makers, that the Council of the North-East Coast Institution of Engineers and Shipbuilders appointed a Committee to investigate the subject, and to devise, if possible, a set of rules which would be generally acceptable. The Committee made its report in the spring of 1888. They took as their basis the indicated horse-power, under certain normal conditions, and propose to call this the normal indicated horse-power (N.I.H.P.). The normal conditions are, briefly, the following:—

(1) That the steam, of whatever boiler pressure, is expanded to the same terminal pressure.

(2) That the expansion is effected by all engines with the same degree of efficiency.

(3) That the piston speeds of engines of different lengths of stroke are proportional to the cube root of their respective strokes, and, further, that the actual loaded trial-trip value of piston-speed may be taken as 144 times the cube root of the stroke in inches ($144 \sqrt[3]{S''}$).

(4) That in cases in which the engines and boilers bear to each other such proportions as to prevent condition (1) from being fulfilled without thereby violating condition (3) the coal consumption per I.H.P. will not be affected, but will be constant for the same boiler-pressure.

(5) That the boilers are constructed in accordance with what will be generally recognized as the average practice of the present day in respect of the allowance of steam room in relation to power, the diameter, area, and pitch of tubes, the relation of grate to heating surface, and the area of uptakes and funnel; that average natural chimney draught is used, or, if forced draught be employed, that it does not exceed the natural draught; that the horse-power is proportional to the heating surface (H), and to the cube root of the pressure ($\sqrt[3]{P}$); and, further, that the actual loaded trial-trip horse-power may be taken as equal to one-sixteenth of the heating surface multiplied by the cube root of the pressure $\frac{(H \sqrt[3]{P})}{16}$.

(6) That the efficiency of the engine mechanism is constant, and that the propeller is such as to secure that the engines will utilize the boiler power referred to in condition (5) in the manner prescribed by conditions (3) and (4).

Subject to these conditions the normal indicated horse-power is found by multiplying the square of the diameter of the low-pressure cylinder in inches by the cube root of the stroke in inches, adding to the product three times the heating surface of the boiler in square feet, multiplying the sum by the cube root of the pressure, and dividing the product by 100.

$$\text{N.I.H.P.} = \frac{(D^2 \sqrt[3]{S} + 3H) \sqrt[3]{P}}{100}.$$

It is evident from this formula, and from the conditions, that account is taken of all the variables, and that the boiler is regarded as an integral part of the engine. The report gives several useful formulæ deduced from the above. Whether the expressions given are the most convenient possible for general marine practice or not, I am not competent to say; but it seems to me that a step has been taken in the right direction in the attempt which has been made to measure marine engines by some rational standard. The members of the Committee were all thoroughly practical as well as scientific men; they determined their constants by reference to a large number of successful cases; and I sincerely hope that the question will be pursued by the marine engine builders on the west coast, and by the constructors of land engines. As engineer to the Royal Agricultural Society, I have frequently had to define the power of engines entered for competition for the Society's prizes, and I have experienced the greatest difficulty in laying down rules for the guidance of intending competitors, being fearful, on the one hand, of restricting originality, and, on the other, of admitting engines of greatly varying powers.

I have expressed an opinion that the numerous engineering Societies which exist at this day have it in their power to promote the advancement of mechanical science in a notable manner by appointing Research Committees, or by aiding individual investigations from their abundant means. The North-East Coast Institution of Engineers and Shipbuilders has done good service in their endeavours to establish a practical measure of the power of marine engines, while the Institution of Mechanical Engineers has, for the last ten years, been steadily promoting researches of an eminently practical nature. Their expenditure has reached the handsome sum of £1700, and their Proceedings have been enriched with Reports on the hardening, tempering, and annealing of steel, on the form of riveted joints, on friction at high velocities, on marine-engine trials, and on the value of the steam jacket. The names of those who are acting on these Committees are a guarantee that the investigations conducted by them will rank among the classical works of the profession, and will abundantly justify the liberal expenditure which has been incurred.

It is impossible to conclude the address which I have had the honour of delivering, without an allusion to the most important structure which engineering skill and enterprise has ever attempted. The Forth Bridge is rapidly approaching completion, and on Saturday, September 14, Mr. Baker is to deliver a lecture, in which he will, no doubt, tell us when the great work is likely to be completed. I think that the members of this Section belong sufficiently to the "working classes" to have a claim to admission to the lecture, and to hear from the lips of the creator of the bridge the story of its inception, of its progress, and his hopes as to its completion.

NOTES.

THE International Congress of Astronomy commenced its sittings in Brussels on the 10th inst., under the presidency of M. Hugo Gyldén, Director of the Observatory of Stockholm. Among the English members are Mr. Downing, of the Greenwich Observatory, and Mr. Ranyard, of London. The Minister of Railways welcomed the Congress in the name of the Belgian Government. Munich has been fixed as the place for the next meeting.

INFORMATION has come from the United States of terrible wind and rain storms on the 10th, 11th, and 12th inst., all along the North Atlantic coast, doing immense damage. Coincidently with this came the report of serious internal disturbances in the Yellowstone region, putting the entire geyser system in a violent outbreak. Several long dormant geysers are in a state of furious activity.

A CIRCULAR from the Local Government Board to all the District Boards and Vestries in the Metropolis, an order prescribing a form of notification for use by medical practitioners, and a memorandum for their guidance, have been issued, under the provisions of the Infectious Disease (Notification) Act, 1889. The Act comes into force in the Metropolis on October 30.

THE subject for the Sedgwick Prize Essay at Cambridge to be awarded in 1892 is "On Fossil Plants as Tests of Climatic Conditions." The prize is open to all graduates of the University of Cambridge who shall have resided sixty days during the twelve months preceding October 1, 1891. The essays must be sent to the Registrary of the University on or before October 1, 1891, each bearing some motto and accompanied by a sealed paper bearing the same motto and inclosing the name and College of the candidate.

WE have received from Reykjavik a copy of the rules of a Society just established there, under the presidentship of Prof. B. Gröndal, called the Icelandic Naturalists' Society, the chief aim of which is to found a museum of natural history for Iceland, to be the property of the country. For this purpose it is not only intended to collect specimens of the fauna, flora, and mineral deposits of Iceland, but also to obtain by exchange, or in any other convenient manner, specimens from abroad.

THE *Times of India* reports that a meteorological observatory is to be established at Perim, at the Aden entrance to the Red Sea.

THE annual examination, held under the direction of the State Medicine Syndicate, from the result of which diplomas in public health are granted, will commence at Cambridge on Tuesday, October 1. Any person whose name is on the Medical Register of the United Kingdom may present himself, provided that he is in his twenty-fourth year at least when he presents himself for the first part of the examination, and has attained twenty-four years of age when he presents himself for the second part. The examination in each part occupies two days, and is oral and practical as well as in writing. Candidates may present themselves in either part separately or for both together at their option, but the result of the examination in the case of any candidate will not be published until he has passed both parts. Every candidate who has passed both parts receives a diploma testifying to his competent knowledge of what is required for the duties of a medical officer of health. All applications for admission to the examination, or for information respecting it, should be addressed without delay to Dr. Anningson, Barton Road, Cambridge.

THE additions to the Zoological Society's Gardens during the past week include a Crested Porcupine (*Hystrix cristata*) from India, two Nicobar Pigeons (*Calœnas nicobarica*) from the Indian Archipelago, two Rose-crested Cockatoos (*Cacatua moluccensis*) from Moluccas, a Fork-tailed Jungle Fowl (*Gallus varius* ♂) from Java, presented by Mr. Charles Clifton, F.Z.S.; a Sinaitic Ibex (*Capra sinaitica* ♂) from the Erba Mountains, Suakin, presented by Sir James Anderson; a Zorilla (——) from Suakin, presented by Captain W. W. Bevant; a Vinous Fruit Pigeon (*Carpophaga rufigula*) from the Solomon Islands, presented by Mr. C. M. Woodford; a Wood Owl (*Syrnium aluco*), British, presented by Major Vilett Rolleston, F.Z.S.; an Osprey (*Sandion haliaetus*), European, purchased; a Vulpine Phalanger (*Phalangista vulpina*), born in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *SEPTEMBER* 22–28.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 22

Sun rises, 5h. 48m.; souths, 11h. 52m. 33·4s.; daily decrease of southing, 20·8s.; sets, 17h. 57m.: right asc. on meridian, 11h. 58·7m.; decl. 0° 9′ N. Sidereal Time at Sunset, 18h. 4m.

Moon (New on September 25, 3h.) rises, 2h. 13m.; souths, 9h. 57m.; sets, 17h. 27m.: right asc. on meridian, 10h. 2·9m.; decl. 16° 0′ N.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	8 27	... 13 25	... 18 23	... 13 31·5	... 12 41 S.
Venus ...	2 25	... 9 41	... 16 57	... 9 47·2	... 13 54 N.
Mars ...	2 52	... 10 2	... 17 12	... 10 8·0	... 12 50 N.
Jupiter ...	13 59	... 17 52	... 21 45	... 17 58·7	... 23 29 S.
Saturn ...	2 46	... 9 58	... 17 10	... 10 39	... 13 12 N.
Uranus ...	7 47	... 13 12	... 18 37	... 13 18·2	... 7 39 S.
Neptune..	20 17*	.. 4 7	... 11 57	... 4 11·5	... 19 25 N.

* Indicates that the rising is that of the preceding evening.

Sept.	h.	
22 ...	2 ...	Venus in conjunction with and 3° 12′ south of the Moon.
22 ...	10 ...	Saturn in conjunction with and 2° 44′ south of the Moon.
22 ...	13 ...	Mars in conjunction with and 2° 47′ south of the Moon.
22 ...	21 ...	Sun in equator: day and night of equal length.
26 ...	8 ...	Venus in conjunction with and 0° 34′ south of Saturn.
26 ...	21 ...	Mercury in conjunction with and 8° 38′ south of the Moon.

Variable Stars.

Star.	R.A.	Decl.		
	h. m.	° ′		h. m.
U Cephei ...	... 0 52·5	... 81 17 N.	... Sept. 25,	4 7 *m*
λ Tauri... ...	... 3 54·5	... 12 11 N.	... ,, 27,	3 15 *m*
U Coronæ ...	... 15 13·7	... 32 3 N.	... ,, 23,	19 8 *m*
U Ophiuchi...	... 17 10·9	... 1 20 N.	... ,, 23,	3 50 *m*
			and at intervals of	20 8
T Vulpeculæ	... 20 46·8	... 27 50 N.	... Sept. 22,	2 0 *m*
X Capricorni	... 21 2·2	... 21 48 S.	... ,, 24,	*M*
T Capricorni	... 21 15·9	... 15 38 S.	... ,, 25,	*M*
δ Cephei ...	... 22 25·1	... 57 51 N.	... ,, 27,	1 0 *M*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near α Arietis...	30°	... 18° N.	
	98	... 43 N.	... Very swift; streaks.
From Lynx	115	... 52 N.	... Very swift.

CONTENTS.

THURSDAY, SEPTEMBER 26, 1889.

THE TERTIARY FLORA OF AUSTRALIA.

Contributions to the Tertiary Flora of Australia. By C. von Ettingshausen. Memoirs of the Geological Survey of New South Wales. (Sydney: Charles Potter, 1888.)

THE work consists of translations from the German originals of two memoirs, published respectively in 1883 and 1886, with explanatory notes on the geology by the Survey officers. Ettingshausen's contribution consists of about 170 pages of "exact determinations of fossils" and a few pages of theoretical considerations and tabulated lists. In these we are informed that the "Tertiary floras" formed one universal flora, which spread over all lands outside the tropics, and "that in this flora all the elements of the different floras of the world are found combined" (p. 3). The "Tertiary period," from this point of view, consists of sub-periods of uniform conditions, susceptible of exact classification and correlation, with an orderly beginning and definite close. From another point of view it is a period of the world's history, so stupendous, so broken and diversified, that we can never hope to reconstruct a complete history from its imperfect records, and to marshal its secrets into exact order. Embraced in its vast folds are sediments, perhaps coæval with our chalk, beginning when much that is now land was the abyssal depths of ocean, and enduring while continents and seas slowly changed their places. Its episodes were the joining hands of widely severed lands and the parting of them again asunder into isolated tracts, until at last it saw the existing continents settling into their present form. So enormous was its duration, that its "newer" periods sufficed to raise and scarp the loftiest mountain ranges of the world; and its close to submerge and re-elevate again and again, to trim, alter, and finally cut into separate islands the insignificant portion of the globe we inhabit as Great Britain. During all which time, floras as distinctive as any of those now existing were swayed hither and thither by the changing climatic conditions accompanying the oscillations of land and water—here picking up recruits on their passage, and there deserted by the worn out; here coalescing with distinct hosts who struggled and thinned, or swelled, each other's ranks, and there dwindling in numbers as stations or habitats became submerged and broken up. As well might we try to arrive at a complete history of the feuds and migrations of Palæolithic man, as of the floras of the "Tertiary period," for at most each country can but contribute a few isolated facts regarding the floras that have passed over it. Thus, though we possess a broken record in the Isle of Wight of 3000 feet of Tertiaries, mostly deposited under conditions extremely favourable to the preservation of plants, this has, in the island, yielded an adequate idea of its forest vegetation for about 6 inches of its thickness. Nevertheless, remains of floras are repeatedly sandwiched in our Eocenes. These begin abruptly, with nothing leading up to them; and if we go to Ireland and Scotland we can supplement them with other 3000 feet of volcanic rocks with still older floras sandwiched among them, but affording no beginning to the "Tertiary formation." And our series ends abruptly, leaving an enormous gap of most critical time unrepresented between Oligocene and Pliocene, yet having revealed flora after flora as utterly distinct from each other as those of the antipodes, and with scarce any elements in common. Thus, however such conditions may have obtained in Carboniferous times, this theory of a uniform flora or fauna spreading, during the Tertiaries, over both hemispheres, from the limits of vegetation to the confines of the tropics, is altogether outside practical science, and simply leads to affinities being discovered between imperfectly preserved common types of vegetable organisms, where none such perhaps exist.

With regard to the 170 pages of "exact determinations of fossils," though no species-makers are so prolific as palæo-phytologists, our author certainly bids fair to beat the record, for *sp. nov.* is attached to as many of the fragments as the limits of the collection would well allow. The three ferns and three monocotyledons are negative, if unsatisfactory, but there would have been one less belonging "undoubtedly to the Monocotyledones," had not a stray Carboniferous specimen been included in the consignment. The single Cycad is a *sp. nov.*, bearing "a remarkable and specific relation" to a North Greenland fossil. The Coniferæ are determined on very poor material, but most are considered as at least allied to Australian forms; yet *Sequoia* is imported when the native *Athrotaxis* would better meet the case. A new genus, *Heterocladiscos*, is actually founded on some insignificant cupressineous foliage only, and another, *Pseudopinus*, is certainly curious if its supposed fruits are cones and not catkins. Of the some 150 new dicotyledons, the vast bulk would be classed as indeterminable fragments by any reasonably cautious palæontologist. The less characterized of these figure as the exotics to Australia, whilst the most satisfactory are found among the Proteaceæ and other Australian forms as *Boronia*, *Eucalyptus*, species of *Piper*, *Ceratopetalum*, &c. Many of the species are founded on single fragments, sometimes without base or tip, and unless the plates do them injustice, with scarcely any visible venation or character.

We cannot judge of the difficulties of collecting, but it certainly appears that if it is worth while to publish anything on fossil plants at the Government expense, it would be worth while to gather proper material for it. When broken specimens of leaves are obtainable, entire ones can as a rule be extracted, and when these are to hand, though exotic genera may well have flourished in Australia as in Europe in bygone ages, it will be surprising if more of them cannot be matched with plants nearer their own home.

J. STARKIE GARDNER.

OUR BOOK SHELF.

Useful Rules and Tables. By William J. M. Rankine. Seventh Edition, revised by W. J. Millar, C.E. (London: C. Griffin and Co., 1889.)

THIS is the seventh edition of a work which at the present day is almost indispensable to engineers in general. The increase and development of mathematics, year by year, and also the greater tendency towards accurate results, call for a book containing all the various rules and tables relating to those parts of mathematical and mechanical science whose application most frequently occurs in the useful arts, and especially in engineering and practical mechanics. In this volume of moderate bulk, such a work has been provided. The use of algebraical symbols has been avoided as much as possible, excepting in those cases in which the rules cannot be clearly expressed without them.

The book is divided into ten parts. The first deals with arithmetic and mensuration, including tables of cubes, squares, logarithms, a summary of the rules in trigonometry, with tables of arcs, sines, &c., concluding with the measurement of areas of surfaces, volumes of solids, and lengths of curves, &c. Part 2 treats of the measures of different nations, with tables and rules relating not only to measures of angles, time, length, surface, &c., but to those of speed, heaviness, pressure, work power, &c. Engineering geodesy, distributive forces and mechanical centres, balance and stability of structures, and strength of materials are included in the next four parts. Part 7 relates to machines in general, and gives rules for the comparison of the motions of different parts of a machine, and for the designing of teeth of wheels, speed cones, &c., with rules relating to work at uniform and variable speed. Parts 8 and 9 treat of hydraulics and heat, together with the steam-engine. The former includes rules for flow of water, prime movers, propulsion of vessels, &c.; the latter consists of tables of elasticity, volume, and specific heat of gases, factors of evaporation, with rules relating to furnaces, boilers, expenditure of heat in cylinders, efficiency of strain, &c.

Part 10, written by Andrew Jamieson, has been revised and considerably extended, and consists of electrical rules, tables, and formulæ. The information has been brought up to date as much as possible, and many points of difficulty, such as directions of currents, magnetic force and motion, are made clear by means of illustrations. Electrical engineering symbols and units of measurement, heat, and light are first given. These are followed by various forms of Wheatstone bridges, apparatus for testing electric light cables, the wire-testing batteries on the General Post Office system, tables of resistance, general data of the different submarine cables and batteries.

In the appendix there is a useful diagram of the mechanical properties of steam, showing the absolute pressure in pounds per square inch, and volumes in cubic feet per pound of dry saturated steam, and the mean absolute pressure, in decimal parts of absolute pressure of admission. A complete index adds greatly to the value of the work; and we may say that the more one looks through the pages of the book the more one is struck by the large amount of useful information collected together in these 456 pages.

Colour. By C. T. Whitmell. (Cardiff: Wm. Lewis, 1888.)

THIS book is designed for the general reader, and is, on the whole, well suited to this class of person. The principal drawback it possesses is unquestionably the want of a good index, while the division into short numbered sections of in many cases a few lines only is very inconvenient, and produces a sensation of discontinuity of subject. Some parts are excellently done, notably the illustrations given of irregular reflection by turbid media, the description of colour produced by absorption, and the part dealing with colour-blindness. In connection with this last subject much extension of our knowledge would no doubt result from systematic observation of the progressive development of colour-blindness in cases of locomotor ataxy.

It is to be regretted that the author did not supply coloured diagrams to at least some of the sections, or failing this it would be more suggestive in the diagrams of light transmitted through different specimens of coloured glass to shade the part representing the absorbed and to leave unshaded that representing the transmitted light. Some preliminary description of the optical apparatus employed would be also serviceable, *e.g.* in section 10 the reader is told the properties of a spectrum produced by a diffraction grating, no reference being made until much later, and then a very incomplete one, as to the principle involved in the formation of the spectrum.

The book is fairly up to date, containing as it does reference to Langley's bolometric observations and to König's researches on the theory of colour vision. Interesting cases are given of errors due to ignorance of scientific principles; and in view of the frequency of their occurrence—perhaps more noticeably from neglect of the effects of refraction than of the principles of colour—it is regrettable that manuals such as Church's, Rood's, or this, are not more generally read by painters.

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.*]

Sailing Flight of Large Birds over Land.

IT gave me great pleasure to see, by Lord Rayleigh's letter in NATURE of May 9 (p. 34), that the remarks made by me some months ago on this subject were not made in vain.

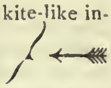
Ever since 1863, the sailing flight of large birds (which is here very common) has been a subject of observation to me, and odd notes have been sent home to the *English Mechanic* and to the Aëronautical Society (see Sixteenth Report, 1881, pp. 10-17).

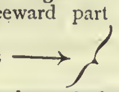
Mr. A. Baines, in NATURE of May 2 (p. 9), well describes the sustained sailing of the albatross, indicating what I take to be the *vera causa, i.e.* the rising, kite-like, when it sweeps round to meet the wind, the energy of motion being gained by descending *with it* along an incline. But this problem, as seen among the sea-birds, seems to be complicated by the possibility of lifting action due to the waves; and, in Mr. Baines's letter, by different velocities of the air near the sea surface and at elevations of 20 feet or so. Out here, these two features are not only eliminated, but we see the bird doing more work.

The sea-birds merely sustain for hours a given weight, say twenty pounds, without flapping the wings, whereas the land-birds lift this twenty pounds, in two or three hours, to a height of 1 or 2 miles vertically, as well.

The adjutants (*Leptotilus argala* and *nudifrons*), the cyrus, pelican, vultures of several kinds, and storks, habitually rise here during fine weather, if there is a wind. At first they rise by flapping the wings vigorously, and, when 200 or 300 feet up, gradually begin to sail in huge right- or left-hand spirals, rising 30 or 40 feet at each lap. When seen thus, the wings are rigidly extended, and tail spread, the primary wing-feathers distinctly separated, and a loud musical tone is heard as the bird sweeps round and round overhead. If low down, they can be closely studied through a binocular, but if at a great height, I generally use a telescope, 3″·5 O.G., and terrestrial eye-piece, power 40. With this latter I can follow them, either in a group or singly, until each is a mere speck, and the elevation can be fairly calculated, when the spread of wing is often 8 or 9 feet × 1½.

Our prevailing north-east wind, and also our south-west monsoon, are particularly steady air-drifts of, say, 5 or 6 to 10 miles per hour, and I should doubt very much, if, after 500 feet up, there is any variation in the speed at different heights. The lifting due to occasional waves should also here be out of the question, and under these conditions I would ask Lord Rayleigh where we could possibly obtain the "energy of position" if it is not from the kite-like action? In my former note, to which he refers, I think a small diagram illustrated the slow drift to leeward as the bird rose by sailing in spirals.

I should say, perhaps, that the birds maintain the kite-like incline, *all round the windward portion* of the spiral, thus 

and appear to gain elevation in sweeping round while thus at an angle; at first facing the breeze, and as they sweep round being side on, as per diagram, the centrifugal element coming into play. If very low down, indeed, the bird can be seen to rise distinctly as it wheels round the windward edge of the curve, and reaches its greatest elevation just as it turns tail to wind. Then it seems to shoot along down a slight incline with wings horizontal, and in rounding the leeward part of the spiral, the outer wing is again spiral, thus . The speed of the bird so greatly exceeding that of the wind, renders this necessary to enable it to turn.

Viewed from below, the tracks look circular, and often vary in size a good deal.

In all cases, so far as I have seen, these birds when rising, as they sail round and round, make leeway, say a mile for every 1000 feet rise, or less.

They never rise on a straight course, though they often descend in a straight line, and, after a time, flocks that drift over the hills recover their position over the plains by descending to windward.

But in all these cases of land-birds rising steadily as they sail round and round, there is no possibility of lifting by waves, as at sea, nor yet differences in the *speed of air strata* every 20 feet or so, as they sail at all heights, from 500 feet up to 10,000 or more.

The problem is much more clearly seen, and more wonderful, than in the case of the albatross, and, as far as I can see, the explanation which I gave years ago is the only one feasible. The momentum gained in descending a given distance *with the wind* is expended in lifting the bird kite-like as it turns and *faces* the wind, on the shorter windward course, where also a certain amount of centrifugal reaction comes into play and does some of the *work*.

S. E. PEAL.

Sibsagar, Assam, August 8.

Bishop's Ring and Allied Phenomena.

Is there any connection between the sunset glows seen by Mr. S. E. Bishop in the Sandwich Islands (see p. 415) and the phenomena which have occurred lately in Western Europe? There has been for two months a feeble reappearance of a great corona round the sun. I do not know whether I can call it Bishop's ring, as it has generally been larger than that caused by the Krakatão dust, and also more dirty-looking in colour, and doubtless at a lower level. Bishop's ring itself had never altogether ceased to be visible about sunset and sunrise, but I had not certainly seen it at any time when the sun has had a considerable altitude for nearly two years, and then only in the clear Alpine air. On May 14 and August 26, 1888, there was indeed a great corona, but on the latter occasion the air was not very clear, so I concluded it probably had some other cause than volcanic dust; and there have been a few other occasions before that when I have had the same impression. On May 14, 1888, it is also questionable whether the circle was caused by volcanic dust.

The present corona appeared all at once on June 30 last, while I was at Macugnaga, at the foot of Monte Rosa; and since that date, both travelling in the Alps and here (since I came home on August 8) it has continued more or less visible at all times of the day when not obscured by mist or smoke, except from the afternoon of July 1 until the afternoon of the 2nd. It is plainest about sunset. It first appeared on cloudy streaks like very thin indefinite cirrus, but these disappeared during July 1. Since it appeared the sky has never been such a pure blue as it was before; this applies to all altitudes from sea-level to 10,000 feet.

I have not seen any remarkable sunset phenomena, so that it seems difficult to connect this circle with the phenomena noticed by Mr. Bishop a fortnight later than this commenced; still the connection is not impossible, as he mentions seeing the central (and by far the brightest) part of the corona.

Although it is improbable that the dust of Krakatão can have entirely settled to the ground, the above description will show that the present phenomenon can hardly be caused by it; but there must be a very extensive diffusion of some kind of dust—it may be one of the kinds alluded to by Prof. Tyndall and others in the discussion which occurred in your pages last year.

Sunderland, September 21. T. W. BACKHOUSE.

OBSERVATIONS OF TWILIGHT AND ZODIACAL LIGHT DURING THE TOTAL ECLIPSE OF THE SUN, DECEMBER 21, 1889.

THE attention of all friends of astronomy and meteorology, and especially of navigators on the ocean, and of meteorological observers in India and Mexico, is respectfully called to the fact that they may make valuable observations during the coming total eclipse of the sun. The observations referred to are of a most elementary character, and pertain to the phenomena of twilight and of the zodiacal light. The importance of the observations to be described was first appreciated by German meteorologists, and the following paragraphs are based upon suggestions made by Prof. Bezold and Dr. Zenker, of Berlin.

On December 22, 1889, at 47 minutes before noon, Greenwich time (which corresponds with 6 hours and 13 minutes a.m. of standard Eastern time) our globe becomes tangent to the long cone that constitutes the shadow of total darkness behind the moon, and we say that "totality has begun on the earth"; this occurs at a point in the Caribbean Sea, north of Venezuela, at about 15° N. lat. and 72½° W. long. In about three hours and a quarter this zone of total eclipse has passed the earth; its last point of contact, or tangency, occurs at a point on the eastern coast of Africa at about 5½° N. lat. and 49° E. long. The path of totality on the earth's surface between these two limits is a narrow belt, about 100 miles broad, and astronomers will station themselves at favourable localities in order to observe the phenomena visible immediately around the sun, but meteorologists and local amateurs residing entirely outside the path of totality can also do good work.

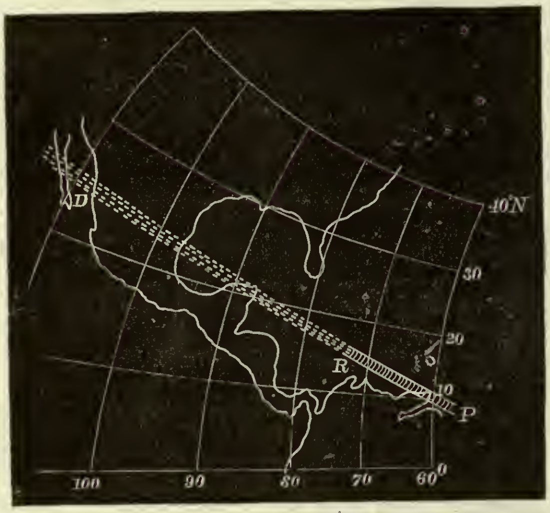
The accompanying diagrams, I., II., III., IV., will illustrate the conditions of the eclipse and the nature of the meteorological observations desired to be made. Thus in diagram I. we see the point R, or the locality where the totality begins to an observer on the earth; at that point the sun rises while it is totally eclipsed, and the band from R to P shows the path of the shadow as it flies eastward. Diagram II. takes up the path at its other end, and shows it still moving eastward from P towards S, where it finally leaves the earth, so that an observer at S sees the sun in his western horizon, but totally eclipsed as it is setting out of sight.

If we now imagine a vertical plane passing through the observer and the eclipsed sun, it will give us a section of the earth, its atmosphere, and the cone of darkness very much as shown in diagrams II. and IV. In diagram II. R represents, as before, the locality where the sun rises eclipsed, the moon is to the east of the observer, and the cone of darkness passes over him towards its apex, which is far off towards the west. Those who are located to the west of R, as at D, looking eastward, cannot see the sun because it is below their horizon; they can see only the light of the morning dawn where the sun is about to rise, but these observers, if they look directly toward the brightest part of the dawn, immediately over the sun, will, on this morning of December 22, find that they are looking right into the shadow of the cone, and will therefore observe that the light of the dawn is for a few minutes much feebler than usual.

Similarly diagram IV. shows the condition of things at the point S, where the observer at sunset has the cone of darkness imediately above him; observers to the east of his location, as at T, will be enjoying twilight, and as they look toward the west, immediately above the sun, they will be looking into the cone of darkness, and will find the twilight correspondingly diminished.

The distance from K to D in Fig. 1, and from S to T in diagram II., represents about 35° or 40° of the great circle, or over 2000 miles on the earth's surface; all persons located in this immense region—namely, all on vessels in the Caribbean Sea and Gulf of Mexico, the Arabian Sea—and all meteorological observers in Northern Mexico, Yucatan, Jamaica, and Western India, should be on the watch for phenomena of the following kind:—

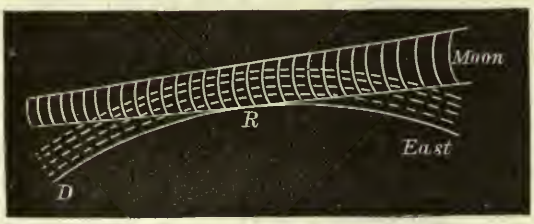
(1) Note when the moon's shadow becomes first or last



I.

visible by the darkness of the high cirrus, haze, or the tops of cumulus clouds or the tops of mountains.

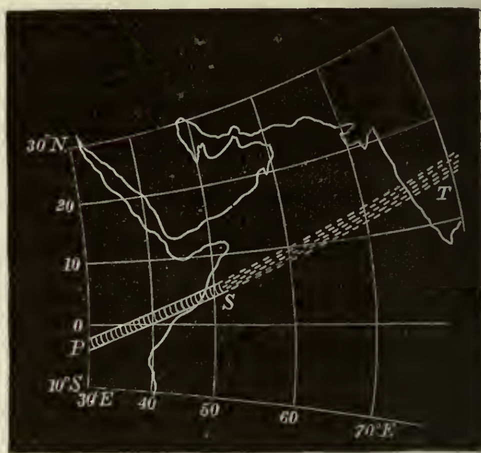
(2) When the darkness is at its maximum, its boundary appears as a curved band of colours convex to the horizon, disturbing the otherwise horizontal arrangement of the illumination that constitutes the dawn or twilight. Note the angular distance of this boundary above the horizon at several points to the right and left of the sun. Note also the colours and their arrangement, both in the twilight proper and in the shaded portions. Note especially how far to the right or left the disturbance of the twilight



II.

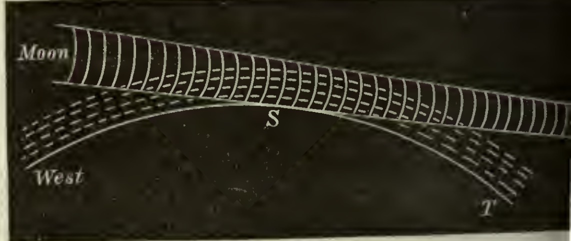
or dawn appears to extend. By distance, of course, is meant apparent angular distance; but if the observer is so located that distant mountain-tops are visible, he should note whether they also show any phenomena due to the moon's shadow.

(3) Owing to the fact that the observers at D and T are looking through a portion of atmosphere that does not receive its ordinary amount of light from the sun, they will be able to see objects that ordinarily would be hidden by the glare of twilight, such as fainter stars, and especially the Milky Way, and the zodiacal light. The latter object is one of special interest. It is desirable that observers should carefully record the appearance of zodiacal light for several days before and after the eclipse, as also on the 22nd itself, in order that we may distinguish between local atmospheric effects and those due to the eclipse. During the morning dawn in the region R D, and during the twilight S T, one should observe that the zodiacal light attains an unusual brilliancy and extent; the points to be noted are, first, how much further up from the horizon, or from the sun, is the beam of zodiacal light visible during the few minutes when the cone of shadow comes between it and the observer;



III.

again, how much nearer down toward the sun does it extend; and, again, how much broader is it toward the right and left? Does its colour appear changed? Sometimes several portions of the zodiacal light appear brighter than the neighbouring regions, therefore observe whether, as seen through the conical shadow, these differences disappear and the whole zodiacal light has a uniform gradation in intensity from the sun outward toward its extremity. Sometimes pulsations or waves of brightness and darkness have appeared to proceed from near the sun, reaching the extremity of the zodiacal light



IV.

in the course of five or ten seconds; note whether any such phenomena are visible.

The zodiacal light has been, on good authority, observed very high above the east and west horizon, so that some maintain that it is continuous through the zenith, and therefore surrounds the earth. This view may possibly be tested by observers located anywhere near the equator and a long way off from the path of totality. Therefore everyone should keep a record of the zodiacal light if he is so located as to see it at all during a few days before and after the eclipse and several hours before sunrise and after sunset. If observations show that the brightness of the zodiacal light is materially diminished during totality, in any part of the region where the moon's shadow darkens the atmosphere, this will go far to show that the zodiacal light originates in the earth's atmosphere; but if, as seen through the shaded air, the zodiacal light appears brighter than ever, it would follow that its location is far from us, and that it is an appendage of the sun.

(4) The observers of the zodiacal light should not fail to record the phenomena sometimes seen on the opposite side of the horizon, and called *Gegenschein*, or the anti-zodiacal light. Similarly, observers of the twilight phenomena should record the appearances in the horizon at the opposite side of the sun, or the so-called anti-twilight arc, or band.

(5) Observers to whom the sun is beyond the horizon, and for whom the atmosphere between them and the sun is not illumined owing to the presence of the moon's shadow, will have a good opportunity, for a few minutes, to see any faint comet that may have been hidden to astronomers by the glare of the sunlight, and, if such should be seen, they should record the apparent altitude and azimuth of the nucleus.

The diagrams I. and III. trace the shadow-cone westward to South California and eastward to India, but this should not prevent observers still further west on the Pacific, or east over India and Japan, from recording and reporting such phenomena as they may observe.

Washington, August. CLEVELAND ABBE.

THE BRITISH ASSOCIATION.

SECTION D.

BIOLOGY.

OPENING ADDRESS BY PROF. J. S. BURDON SANDERSON, M.A., M.D., LL.D., F.R.SS. L. & E., PRESIDENT OF THE SECTION.

IT has long ceased to be possible in the course of an annual address in Section D to give an account even of the most important advances which have been made during the preceding twelve months in the various branches of knowledge which are now included under the term Biology. One reason is that each of the biological subjects has acquired such vast dimensions; the other, that the two main branches—Morphology, which strives to explain why plants and animals have assumed the forms and structure which they possess, and Physiology, which seeks to understand how the living organism works—have now diverged from each other so widely as regards subject and method, that there seems to be danger of complete separation of the one from the other.

From this sundering of sciences which a generation ago were intimately united, however inevitable it may be, Physiology chiefly suffers, as being even to the naturalist less attractive and interesting. The study of form and structure has the great advantage that it brings the observer into direct relation with objects which excite his curiosity without requiring too great an effort to understand them. This was the case even when Anatomy was mainly descriptive, and Zoology and Botany occupied themselves chiefly with classification and with definition of species. How much more is it the case now that Anatomy, Zoology, and Botany have become built into one system, of which the Doctrine of Evolution is the corner stone! Morphology, the name now given to this system, has, if I am not mistaken, this advantage over all other subjects of scientific study —that while attractive to the beginner, it is perfectly satisfactory to the mature student. It derives its perfectness from its subject —the *order* of the plant and animal world. For inasmuch as its fundamental conception is the development of all organisms, however complicated, from elementary forms, and as the theoretical development of the plant and animal world (in other words the science of morphology), claims to be nothing more than a synthesis of the observed facts of its actual development, the science is co-ordinate and conterminous with living nature, and strives after a perfection which is that of nature itself.

Physiology is without this source of attractiveness. Its first lessons present difficulties to the beginner which, unless he is contented (as, indeed, ordinary students are) to accept as true what he does not understand, are, to say the least, discouraging; while to the more mature student, who has mastered more or less some part of the subject, it fails to present a system of knowledge of which all the parts are interdependent and can be referred to one fundamental principle, comparable to that of development or evolution.

It is easy to understand that this must be so if we consider the present position of the subject, and the nature of the work which the physiologist has to do. That work is of two kinds. He has first to determine what are the chemical and physical endowments of living matter in general, and of each of the varieties of living matter which constitute the animal and plant organism in particular. Then, these having been investigated, he has to determine how these processes are localized so as to constitute the special function of each structure, and the relation between structure and process in each case. The order I have indicated is the logical order, but in the actual progress of physiology this order has not been followed, *i.e.* there has not been a correlation of structure with previously investigated process, for in former days physiologists spoke of assimilation, secretion, contraction, and the like, as functions of muscles, glands, or other parts, without recognizing their ignorance of their real nature. But now, no one who is awake to the tendencies of thought and work in physiology, can fail to have observed that the best minds are directed with more concentration than ever before to those questions which relate to the elementary endowments of living matter, and that if they are still held in the background it is rather because of the extreme difficulty of approaching them than from any want of appreciation of their importance.

It is to some of these questions that I am anxious to draw the attention of the Section to-day. I feel that I have set myself a difficult task, but think that, even should I succeed very partially, the attempt may be a useful one. And I am encouraged by the consideration that the interest they possess is one which is common to plant and animal physiology, and that if we really understood them, they would furnish a key, not only to the phenomena of nutrition and growth, but even to those of reproduction and development, and by the belief that it is in the direction of elementary physiology, which means nothing more than the study of the endowments of living material, that the advance of the next twenty years will be made.

Nearly fifty years ago, J. R. Mayer's [1] treatise on the relation between organic motion and the exchange of material in living organisms was published in Germany. Although its value was more appreciated by physicists than by biologists, it was in its purpose, as well as in its subject-matter, physiological. In it Mayer showed for the first time that certain functions of the animal body, which up to that time had been considered most vital, are strictly within reach of measurement, *i.e.* referable to physical standards of quantity. He was even able to demonstrate that those quantitative relations between different kinds of energy which physicists were then only beginning to recognize, held good as regards the processes peculiar to the living organism.

Almost immediately after the appearance of this now celebrated work, a series of discoveries were made in physiology, which constituted the period we are now considering an epoch. Mayer himself had proved that muscles in doing work and producing heat do not do so at the expense of their own substance. But this fact could not be understood until Bernard showed that sugar is one of the most important constituents of the blood, and its storage and production a chief function of the liver. Helmholtz next succeeded in proving what Johannes Müller [2] had declared to be nearly impossible—namely, that the time occupied by the propagation of a motor impulse from the brain to a muscle could be measured, and showed it to be proportional to the distance traversed. Next, du Bois-Reymond investigated the electrical phenomena of living beings, and marshalled them under a physical theory which stood its ground against the severest criticism for more than a generation. And finally, the hydrodynamic principles relating to the circulation, set forth by Dr. Thomas Young in his Croonian Lecture forty

[1] J. R. Mayer, "Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel" (Heilbronn, 1845).

[2] Müller's "Physiology," translation of second edition, p. 2[illegible].

years before, were demonstrated experimentally by Ludwig, at the very time when Helmholtz was giving definite form to the great natural philosopher's theory of colour perceptions.

The effect of these discoveries was to produce a complete revolution in the ways of thinking and speaking about the phenomena of life. The error of the past had been to believe that, although the heart resembled a pump, although digestion could be imitated in the laboratory, and comparisons of vital with physical processes could be used for illustration, it was always wrong to identify them. But, inasmuch as it had been learned that sensation is propagated along a nerve just as sound is propagated through the air, only with something like a tenth of the velocity, that the relations between the work done, the heat produced, and the fuel used, can be investigated in the living body just as they are in the steam-engine, it now came to be felt that, in other similar cases, what had been before regarded as peculiarly vital might be understood on physical principles, and that for, the future the word "vital" as distinctive of physiological processes might be abandoned altogether. In looking back, we have no difficulty in seeing that the lines of investigation which were then initiated by such men as Helmholtz, Ludwig, Brücke, du Bois-Reymond, Donders, Bernard, are those along which, during the succeeding generation, the science of physiology advanced; nor can anyone who is acquainted with the literature of that time doubt that these leaders of physiological thought knew that they were the beginners of a new epoch. But such an epoch cannot occur again. We have adopted once for all the right, *i.e.* the scientific method, and there is not the least possibility of our recurring to the wrong. We have no new departure, no change of front in prospect; but even times which are not epochal have their tendencies, and I venture to submit to you, that in physiology the tendency of the present time is characterized by the concentration of the best efforts of the best minds on what I have already referred to as elementary questions. The work of investigating the special functions of organs, which during the last two decades has yielded such splendid results, is still proceeding, and every year new ground is being broken and new and fruitful lines of experimental inquiry are being opened up; but the further the physiologist advances in this work of analysis and differentiation, the more frequently does he find his attention arrested by deeper questions relating to the essential endowments of living matter, of which even the most highly differentiated functions of the animal or plant organism are the outcome. In our science the order of progress has been hitherto and will continue to be the reverse of the order of Nature. Nature begins with the elementary and ends with the complex (first the amœba, then the man). Our mode of investigation has to begin at the end. And this not merely for the historical reason that the first stimulus to physiological inquiry was man's reasonable desire to know himself, but because differentiation actually involves simplification. For just as in manufactures it is the effect of division of labour that less is required of each workman, so in an organism which is made up of many organs, the function of each is simpler.

Physiology, therefore, first studies man and the higher animals and proceeds to the higher plants, then to invertebrates and cryptogams, ending where development begins. From the beginning her aim has been to correlate function with structure, at first roughly, afterwards, when, as I have explained, her methods of observation became scientific, more and more accurately—the principle being *that every appreciable difference of structure corresponds to a difference of function*; and conversely that each endowment of a living organ must be explained, if explained at all, as springing from its structure.

It is not difficult to see whither this method must eventually lead us. For inasmuch as function is more complicated than structure, the result of proceeding, as Physiology normally does, from structure to function, must inevitably be to bring us face to face with functional differences which have no structural difference to explain them. Thus, for example, if the physiologist undertakes to explain the function of a highly differentiated organ like the eye, he finds that up to a certain point, provided that he has the requisite knowledge of dioptrics, the method of correlation guides him straight to his point. He can mentally or actually construct an eye which will perform the functions of the real eye, in so far as the formation of a real image of the field of vision on the retina is concerned, and will be able thereby to understand how the retinal picture is transferred to the organ of consciousness. Having arrived at this point he begins to correlate the known structure of the retina with what is required of it, and finds that the number of objects which be can discriminate in the field of vision is as numerous as, but not more numerous than, the parts of the retina, *i.e.* the cones which are concerned in discriminating them. So far he has no difficulty; but the method of correlation fails him from the moment that he considers that each object point in the field of vision is coloured, and that he is able to discriminate not merely the number and the relations of all the object points to each other, but the colour of each separately. He then sees at once that each cone must possess a plurality of endowments for which its structure affords no explanation. In other words, in the minute structure of the human retina, we have a mechanism which would completely explain the picture of which I am conscious, were the objects composing it possessed of one objective quality only, being colourless, but it leaves us without explanation of the differentiation of colour.

Similarly, if he is called upon to explain the function of a secreting gland, such, *e.g.*, as the liver, there is no difficulty in understanding that, inasmuch as the whole gland consists of lobules which resemble each other exactly, and each lobule is similarly made up of cells which are all alike, each individual cell must be capable of performing all the functions of the whole organ. But when by exact experiment we learn that the liver possesses not one function but many—when we know that it is a storehouse for animal starch, that each cell possesses the power of separating waste colouring-matter from the blood, and of manufacturing several kinds of crystallizable products, some of which it sends in one direction and others in the opposite—we find again that the correlation method fails us, and that all that our knowledge of the minute structure has done for us is to set before us a question which, though elementary, we are quite unable to answer.

By multiplying examples of the same kind, we should in each case come to the same issue, namely, *plurality of function with unity of structure*, the unity being represented by a simple structural element—be it retinal cone or cell—possessed of numerous endowments. Whenever this point is arrived at in any investigation, structure must for the moment cease to be our guide, and in general two courses or alternatives are open to us. One is to fall back on that worn-out *Deus ex machinâ*, protoplasm, as if it afforded a sufficient explanation of everything which cannot be explained otherwise, and accordingly to defer the consideration of the functions which have no demonstrable connection with structure as for the present beyond the scope of investigation; the other is, retaining our hold of the fundamental principle of correlation, to take the problem in reverse, *i.e.* to use analysis of function as a guide to the ultra-microscopical analysis of structure.

I need scarcely say that of these two courses the *first* is wrong, the *second* right, for in following it we still hold to the fundamental principle *that living material acts by virtue of its structure*, provided that we allow the term structure to be used in a sense which carries it beyond the limits of anatomical investigation, *i.e.* beyond the knowledge which can be attained either by the scalpel or the microscope. We thus (as I have said) proceed from function to structure, instead of the other way.

The departure from the traditions of our science which this change of direction seems to imply is indeed more apparent than real. In tracing the history of some of the greatest advances, we find that the recognition of function has preceded the knowledge of structure. Haller's discovery of irritability was known and bore fruit, long before anything was known of the structure of muscle. So also, at a later period, Bichat was led by his recognition of the physiological differences between what he termed the functions of organic and animal life, to those anatomical researches which were the basis of the modern science of Histology. Again, in much more recent times, the investigation of the function of gland cells, which has been carried on with such remarkable results by Prof. Heidenhain in Germany, and with equal success by Mr. Langley in this country, has led to the discovery of the structural changes which they undergo in passing from the state of repose to that of activity: nor could I mention a better example than that afforded (among many others relating to the physiology of the nervous system) by Dr. Gaskell's recent and very important discovery of the anatomical difference between cerebro-spinal nerves of different functions. We may therefore anticipate that the future of physiology will differ from the past chiefly in this respect—that whereas hitherto the greater part of the work has consisted in the interpretation of facts arrived at in the first instance by anatomical methods of research, Histology, once the guide of Physiology, has now become her handmaid.

During the last ten or fifteen years Histology has carried her methods of research to such a degree of perfection that further improvement scarcely seems possible. As compared with these subtle refinements, the "minute anatomy" of thirty years ago appears coarse—the skill for which we once took credit seems but clumsiness. Notwithstanding, the problems of the future from their very nature lie as completely out of reach of the one as of the other. It is by different methods of investigation that our better equipped successors must gain insight of those vital processes of which even the ultimate results of microscopical analysis will ever be, as they are now, only the outward and visible sign.

In what has preceded, I have endeavoured to show that at present the fundamental questions in physiology, the problems which most urgently demand solution, are those which relate to the endowments of apparently structureless living matter, and that the most important part of the work of the immediate future will be the analysis of these endowments. With this view, what we have to do is, first, to select those cases in which the vital process offers itself in its simplest form, and is consequently best understood; and, secondly, to inquire how far in these particular instances we may, taking as our guide the principle I have so often mentioned as fundamental, viz. the correlation of structure with function, of mechanism with action, proceed in drawing inferences as to the mechanism by which these vital processes are in these simplest cases actually carried out.

The most distinctive peculiarity of living matter as compared with non-living is that it is ever changing while ever the same, *i.e.* that life is a state of ceaseless change. For our present purpose I must ask you, first, to distinguish between two kinds of change which are equally characteristic of living organisms—namely, those of growth and decay on the one hand, and those of nutrition on the other. Growth the biologist calls evolution. Growth means the unfolding, *i.e.* development, of the latent potentialities of form and structure which exist in the germ, and which it has derived by inheritance. A growing organism is not the same to-day as it was yesterday, and consequently not quite the same now as it was a minute ago, and never again will be. This kind of change I am going to ask you to exclude from consideration altogether at this moment, for in truth it does not belong to Physiology, but rather to Morphology, and to limit your attention to the other kind which includes all other vital phenomena. I designated it just now as nutrition, but this word expresses my meaning very inadequately. The term which has been used for half a century to designate the sum or complex of the non-developmental activities of an organism is "exchange of material," for which Prof. Foster has given the very acceptable substitute Metabolism. Metabolism is only another word for "change," but in using it we understand it to mean that, although an organism in respect of its development may never be what it has been, the phases of alternate activity and repose which mark the flow of its life-stream are recurrent. Life is a Cyclosis in which the organism returns after every cycle to the same point of departure, ever changing yet ever the same.

It is this antithesis which constitutes the essential distinction between the two great branches of biology, the two opposite aspects in which the world of life presents itself to the inquiring mind of man. Seen from the morphological side, the whole plant and animal kingdom constitutes the unfolding of a structural plan which was once latent in a form of living material of great apparent simplicity. From the physiological side this apparently simple material is seen to be capable of the discharge of functions of great complexity, and therefore must possess corresponding complexity of mechanism. It is the nature of this invisible mechanism that physiology thirsts to know. Although little progress has as yet been made, and little may as yet be possible, in satisfying this desire, yet, as I shall endeavour to show you, the existing knowledge of the subject has so far taken consistent form in the minds of the leaders of physiological thought that it is now possible to distinguish the direction in which the soberest speculation is tending.

The *non-developmental* vital functions of protoplasm are the absorption of oxygen, the discharge of carbon dioxide and water and ammonia, the doing of mechanical work, the production of heat, light, and electricity. All these, excepting the last, are known to have chemical actions as their inseparable concomitants. As regards electricity, we have no proof of the dependence of the electrical properties of plants and animals on chemical action. But all the other activities which have been mentioned are fundamentally chemical.

Let us first consider the relation of oxygen to living matter and vital process. For three-quarters of a century after the fundamental discoveries of Lavoisier and Priestley (1772–76), the accepted doctrine was that the effete matter of the body was brought to the lungs by the circulation and burnt there, of which fact the carbon dioxide expired seemed an obvious proof. Then came the discovery that arterial blood contained more oxygen than venous blood, and consequently that oxygen must be conveyed as such by the blood-stream to do its purifying work in all parts of the body, this advance in the understanding of the process being crowned a few years later by the discovery of the oxygen-carrying properties of the colouring-matter of the blood, in which the present President of the Royal Society took so prominent a part. Finally, between 1872 and 1876, as the result of an elaborate series of investigations of the respiratory process, the proof was given by Pflüger[1] that the function of oxygen in the living organism is not to destroy effete matter either here or there, but rather to serve as a food for protoplasm, which, so long as it lives, is capable of charging itself with this gas, absorbing it with such avidity, that, although its own substance retains its integrity, no free oxygen can exist in its neighbourhood. This discovery, of which the importance is comparable with that of Lavoisier, can best be judged of by considering its influence on other fundamental conceptions of the vital process. The generally accepted notion of effete matter waiting to be oxidized was associated with a more general one, viz. that the elaborate structure of the body was not permanent, but constantly undergoing decay and renewal. What we have now learnt is, that the material to be oxidized comes as much from the outside as the oxygen which burns it, though the reaction between them, *i.e.* the oxidation, is intrinsic, *i.e.* takes place within the living molecular framework.

Protoplasm, therefore, understanding by the term the visible and tangible presentation to our senses of living material, comes to consist of two things—namely, of framework and of content—of channel and of stream—of acting part which lives and is stable, and of acted-on part which has never lived and is labile, that is, in a state of metabolism, or chemical transformation.

If such be the relation between the living framework and the stream which bathes it, we must attribute to this living, stable, acting part, a property which is characteristic of the bodies called in physiological language ferments, or enzymes, the property which, following Berzelius, we have for the last half-century expressed by the word *catalytic;* and use, without thereby claiming to understand it, to indicate a mode of action in which the agent which produces the change does not itself take part in the decompositions which it produces.

I have brought you to this point as the outcome of what we know as to the essential nature of the all-important relation between oxygen and life. In botanical physiology the general notion of a stable catalyzing framework, and of an interstitial labile material, which might be called catalyte, has been arrived at on quite other grounds. This notion is represented in plant physiology by two words, both of which correspond in meaning—Micellæ, the word devised by Nägeli, and the better word Tagmata, substituted for it by Pfeffer. Nägeli's word has been adopted by Prof. Sachs as the expression of his own thought in relation to the ultra-microscopical structure of the protoplasm of the plant cell. His view is that certain well-known properties of organized bodies require for their explanation the admission that the simplest *visible* structure is itself made up of an arrangement of units of a far inferior order of minuteness. It is these hypothetical units that Nägeli has called micellæ.

Now, Nägeli in the first instance confounded the micellæ with molecules, conceiving that the molecule of living matter must be of enormous size.[2] But, inasmuch as we have no reason for believing that any form of living material is chemically homogeneous, it was soon recognized, perhaps first by Pfeffer, but eventually also by Nägeli himself, that a micella, the ultimate

[1] *Pflüger's Archiv*, vol. vi., 1872, p. 43. and vol. x., 1875, p. 251, "Ueber die physiologische Verbrennung in den lebendigen Organismen."

[2] Nägeli, "Theorie der Gährung; Beitrag zur Molecular Physiologie," p. 121 (1879).

element of living material, is not equivalent to a molecule, however big or complex, but must rather be an arrangement or phalanx of molecules of different kinds. Hence the word tagma, first used by Pfeffer,[1] has come to be accepted as best expressing the notion. And here it must be noted that each of the physiologists to whom reference has been made regards the micellæ, not as a mere aggregate of separate particles, but as connected together so as to form a system, a conception which is in harmony with the view I gave you just now from the side of animal physiology, of catalyzing framework and interstitial catalyzable material.

To Prof. Sachs, this porous constitution of protoplasm serves to explain the property of vital turgescence—that is, its power of charging itself with aqueous liquid—a power which Sachs estimates to be so enormous that living protoplasm may, he believes, be able to condense water which it takes into its interstices to less than its normal volume. For our present purpose it is sufficient for us to understand that to the greatest botanical thinkers, as well as to the greatest animal physiologists, the ultimate mechanism by which life is carried on is not, as Prof. Sachs[2] puts it, "slime," but "a very distensible and exceedingly fine network."

And now let us try to get a step further by crossing back in thought from plants to animals. At first sight, the elementary vital processes of life seem more complicated in the animal than in the plant, but they are, on the contrary, simpler; for plant protoplasm, though it may be structurally homogeneous, is dynamically polyergic—it has many endowments—whereas in the animal organism there are cases in which a structure has only one function assigned to it. Of this the best examples are to be found among so-called excitable tissues, viz. those which are differentiated for the purpose of producing (along with heat) mechanical work, light, or electricity. In the life of the plant these endowments, if enjoyed at all, are enjoyed in common with others.

By the study, therefore, of muscle, of light organ, and of electrical organ, the vital mechanism is more accessible than by any other portal. About light organs we as yet know little, but the little we know is of value; of electrical organs rather more; about muscle a great deal.

To the case of muscle, Engelmann, one of the best observers and thinkers on the elementary questions which we have now before us, has transferred the terminology of Nägeli and Pfeffer as descriptive of the mechanism of its contraction. Muscular protoplasm differs from those kinds of living matter to which I have applied the term "polyergic," in possessing a molecular structure comparable with that of a crystal in the respect, that each portion of the apparently homogeneous and transparent material of which it consists resembles every other.

With this ultra-microscopical structure, its structure as investigated by the microscope may be correlated, the central fact being that, just as a muscular fibre can be divided into cylinders by cross-sections, so each such cylinder is made up of an indefinite number of inconceivably minute cylindrical parts, each of which is an epitome of the whole. These, Engelmann, following Pfeffer, calls ino-tagmata. So long as life lasts each minute phalanx has the power of keeping its axis parallel with those of its neighbours, and of so acting within its own sphere as to produce, whenever it is awakened from the state of rest to that of activity, a fluxion from poles to equator. In other words, muscle, like plant protoplasm, consists of a stable framework of living catalyzing substance, which governs the mechanical and chemical changes which occur in the interstitial catalyzable material, with this difference, that here the ultra-microscopical structure resembles that of a uniaxial crystal,[3] whereas in plant protoplasm there may be no evidence of such arrangement.

According to this scheme of muscular structure, the contraction, *i.e.* the change of form which, if allowed, a muscle undergoes when stimulated, has its seat not in the system of tagmata but in the interstitial material which surrounds it, and consists in the migration of that labile material from pole to equator, this being synchronous with explosive oxidation, sudden disengagement of heat and change in the electrical state of the living substance. Let us now see how far the scheme will help us to an understanding of this marvellous concomitance of chemical, electrical, and mechanical change.

It is not necessary to prove to you that the discharge of carbon dioxide and the production of heat which we know to be associated with that awakening of a muscle to activity which we call stimulation, are indices of oxidation. If we take this fact in connection with the view that has just been given of the mechanism of contraction, it is obvious that there must be in the sphere of each tagma an accumulation of oxygen and oxidizable material, and that concomitantly with or antecedently to the migration of liquid from pole to equator, these must come into encounter. Let us for a moment suppose that a soluble carbohydrate is the catalyzable material, that this is accumulated equatorially, and oxygen at the poles, and consequently that between equator and poles water and carbon dioxide, the only products of the explosion, are set free. That the process is really of this nature is the conclusion to which an elaborate study of the electrical phenomena which accompany it has led one of the most eminent physiologists of the present time, Prof. Bernstein.[1] To this I wish for a moment to ask your attention.

Prof. Bernstein's view of the molecular structure of muscular protoplasm is in entire accordance with the theory of Pflüger and with the scheme of Engelmann, with this addition, that each ino-tagma is electrically polarized when in a state of rest, depolarized at the moment of excitation or stimulation, and that the axes of the tagmata are so directed that they are always parallel to the surface of the fibre, and consequently have their positive sides exposed. In this amended form the theory admits of being harmonized with the fundamental facts of muscle-electricity—namely, that cut surfaces are negative to sound surfaces, and excited parts to inactive—provided that the direction of the hypothetical polarization is from equator to pole, *i.e.* that in the resting state the poles of each tagma are charged with negative ions, the equators with positive; and consequently that the direction of the discharge in the catalyte at the moment that the polarization disappears is from pole to equator.

Time forbids me even to attempt to explain how this theory enables us to express more consistently the accepted explanations of many collateral phenomena, particularly those of electrotonus. I am content to show you that it is not impossible to regard the three phenomena—viz. chemical explosion, sudden electrical change, and change of form—as all manifestations of one and the same process—as products of the same mechanism.

In plants, in certain organs or parts in which movement takes place, as in muscles in response to stimulation, the physiological conditions are the same or similar, but the structural very different; for the effect is produced not by a change of form, but by a diminution of volume of the excited part, and this consists not of fibres, but of cells. The way in which the diminution of volume of the whole organ is brought about is by diminution of the volume of each cell, an effect which can obviously be produced by flow of liquid out of the cell. At first sight therefore the differences are much more striking than the resemblances.

But it is not so in reality, for the more closely we fix our attention on the elementary process rather than on the external form, the stronger appears the analogy—the more complete the correspondence. The state of turgor, as it has been long called by botanical physiologists, by virtue of which the framework of the protoplasm of the plant retains its content with a tenacity to which I have already referred, is the analogue of the state of polarization of Bernstein. As regards its state of aggregation, it can scarcely be doubted that, inasmuch as the electrical concomitants of excitation of the plant cell so closely correspond with those of muscle, here also the tagmata are cylindrical, and have their axes parallel to each other. Beyond this we ought perhaps not to allow speculation to carry us, but it is scarcely possible to refrain from connecting this inference with the streaming motion of protoplasm which in living plant cells is one of the indices of vitality. If, as must I think be supposed, this movement is interstitial, *i.e.* due to the mechanical action of the moving protoplasm on itself, we can most readily understand its mechanism as consisting in rhythmically recurring phases of close and open order in the direction of the tagmatic axes,

In submitting this hypothesis I do not for a moment forget that the facts relating to the contractility of plant cells have as yet been insufficiently investigated. No one has as yet shown that when the leaf of the sensitive plant falls, or that of the fly-trap closes on its prey, heat is developed or oxidation takes

[1] Pfeffer, "Pflanzenphysiologie," p. 12 (Leipzig, 1881).
[2] Sachs, "Experimental-Physiologie," p. 443 (1865).
[3] Brücke, "Vorlesungen," second edition, vol. ii. p. 497.

[1] Bernstein, "Neue Theorie der Erregungsvorgänge und electrischen Erscheinungen an den Nerven- und Muskelfasern," *Untersuchungen aus dem Physiologischen Institut* (Halle, 1888).

place, but it does not seem to me very rash to anticipate that if it were possible to make the experiment to-morrow it would be found to be so.

I have thus endeavoured (building on two principles in physiology, firstly that of the constant correlation of mechanism and action, of structure and function, and secondly the identity of plant and animal life both as regards mechanism and structure; and on two experimentally ascertained elementary relations, viz. the relation of living matter or protoplasm to water on the one hand, and to oxygen and food on the other) to present to you in part the outline or sketch of what might, if I had time to complete it, be an adequate conception of the mechanism and process of life as it presents itself under the simplest conditions. To complete this outline, so far as I can to-day, I have but one other consideration to bring before you, one which is connected with the last of my four points of departure—that of the relation of oxygen to protoplasm, a relation which springs out of the avidity with which, without being oxidized or even sensibly altered in chemical constitution, it seizes upon oxygen and stores it for its own purposes. The consideration which this suggests is that if the oxygen and oxidizable material are constantly stored, they must either constantly or at intervals be discharged, and inasmuch as we know that in every instance without exception in which heat is produced or work is done, these processes have discharge of water and of carbon dioxide for their concomitants, we are justified in regarding these discharges as the sign of expenditure, the charging with oxygen as the sign of restitution. In other words, a new characteristic of living process springs out of those we have already had before us—namely, that it is a constantly recurring alternation of opposite and complementary states, that of activity or discharge, that of rest or restitution.

Is it so, or is it not? In the minds of most physiologists the distinction between the phenomena of discharge and the phenomena of restitution (*Erholung*) is fundamental, but beyond this, unanimity ceases. Two distinguished men, one in Germany and one in England—I refer to Prof. Hering and Dr. Gaskell—have taken, on independent grounds, a different view to the one above suggested, according to which, life consists, not of alternations between rest and activity, charge and discharge, loading and exploding, but between two kinds of activity, two kinds of explosion, which differ only in the direction in which they act, in the circumstance that they are antagonistic to each other.

Now when we compare the two processes of rest, which as regards living matter means restitution, and discharge, which means action, with each other, they may further be distinguished in this respect, that, whereas restitution is autonomic, *i.e.* goes on continuously like the administrative functions of a well-ordered community, the other is occasional, *i.e.* takes place only at the suggestion of external influences; that, in other words, the contrast between action and rest is (in relation to protoplasm) essentially the same as between waking and sleeping.

It is in accordance with this analogy between the alternation of waking and sleeping of the whole organism, and the corresponding alternation of restitution and discharge, of every kind of living substance, that physiologists by common consent use the term Stimulus (*Reiz*, *Prikkeling*), meaning thereby nothing more than that it is by external disturbing or interfering influence of some kind that energies stored in living material are (for the most part suddenly) discharged. Now, if I were to maintain that restitution is not autonomic, but determined, as waking is, by an external stimulus—that it differs from waking only in the direction in which the stimulation acts, *i.e.* in the tendency towards construction on the one hand, towards destruction on the other—I should fairly and as clearly as possible express the doctrine which, as I have said, the two distinguished teachers I have mentioned, viz. Dr. Gaskell [1] and Prof. Hering, have embodied in words which have now become familiar to every student. The words in question, "anabolism," which being interpreted means winding up, and "catabolism," running down, are the creation of Dr. Gaskell. Prof. Hering's equivalents for these are "assimilation," which, of course, means storage of oxygen and oxidizable material, and "disassimilation," discharge of these in the altered form of carbon dioxide and water. But the point of the theory which attaches to them lies in this, that that wonderful power which living material enjoys of continually building itself up out of its environment, is, as I have already suggested, not autonomic, but just as dependent on occasional and external influences or stimuli, as we know the disintegrating processes to be; and accordingly Hering finds it necessary to include under the term stimuli not only those which determine action, but to create a new class of stimuli which he calls *Assimilations-Reize*, those which, instead of waking living mechanism to action, provoke it to rest.

It is unfortunately impossible within the compass of an address like the present to place before you the wide range of experimental facts which have led two of the strongest intellects of our time to adopt a theory which, when looked at *a priori*, seems so contradictory. I must content myself with mentioning that Hering was led to it chiefly by the study of one of the examples to which I referred in my introduction—namely, the colour-discriminating functions of the retina; Dr. Gaskell by the study of that very instructive class of phenomena which reveal to us that among the channels by which the brain maintains its sovereign power as supreme regulator of all the complicated processes which go on in the different parts of the animal organism, there are some which convey only commands to action, others commands to rest, the former being called by Gaskell catabolic, the latter anabolic. To go further than this would not only wear out your patience but would carry me beyond the limits I proposed to myself, viz. the mechanism of life in its simplest aspects. I therefore leave the subject here, adding one word only. The distinction which has suggested to their authors the words on which I have been commenting is a real one, but it implies rather the interference with each other of the simultaneous operation of two regulating mechanisms, than an antagonism between two processes of opposite tendencies carried on by the same mechanism; or, putting it otherwise, that the observed antagonism is between one nervous mechanism and another, and not between two antagonistic functions of the same living material.

Without attempting to recapitulate, I have a word to say by way of conclusion on a question which may probably have suggested itself to some of my audience.

I have indicated to you that although scientific thought does not, like speculative, oscillate from side to side, but marches forward with a continued and uninterrupted progress, the stages of that progress may be marked by characteristic tendencies; and I have endeavoured to show that in physiology the questions which concentrate to themselves the most lively interest are those which lie at the basis of the elementary mechanism of life.

The word Life is used in physiology in what, if you like, may be called a technical sense, and denotes only that state of *change with permanence* which I have endeavoured to set forth to you. In this restricted sense of the word, therefore, the question "What is Life?" is one to which the answer is approachable; but I need not say that in a higher sense—higher because it appeals to higher faculties in our nature—the word suggests something outside of mechanism, which may perchance be its cause rather than its effect.

The tendency to recognize such a relation as this is what we mean by vitalism. At the beginning of this discourse I referred to the anti-vitalistic tendency which accompanied the great advance of knowledge that took place at the middle of the century. But even at the height of this movement there was a reaction towards vitalism, of which Virchow,[1] the founder of modern pathology, was the greatest exponent. Now, a generation later, a tendency in the same direction is manifesting itself in various quarters. What does this tendency mean? It has to my mind the same significance now that it had then. Thirty years ago the discovery of the cell as the basis of vital function was new, and the mystery which before belonged to the organism was transferred to the unit, which while it served to explain everything was itself unexplained. The discovery of the cell seemed to be a very close approach to the mechanism of life, but now we are striving to get even closer, and with the same result. Our measurements are more exact, our methods finer; but these very methods bring us to close quarters with phenomena which, although within reach of exact investigation, are as regards their essence involved in a mystery which is the more profound the more it is brought into contrast with the exact knowledge we possess of surrounding conditions.

If what I have said is true, there is little ground for the apprehension that exists in the minds of some that the habit of

[1] See Gaskell in *Ludwig's Festschrift*, and Hering, "Zur Theorie der Vorgänge in der lebendigen Substanz," pp. 1–22 (Prag, 1888).

[1] Virchow, "Alter und Neuer Vitalismus," *Archiv für pathol. Anat* 1856, vol. ix. p. 1. See also Rindfleisch, "Ärtzliche Philosophie," pp. 10–1 Wurzburg, 1888).

scrutinizing the mechanism of life tends to make men regard what can be so learned as the only kind of knowledge. The tendency is now certainly rather in the other direction. What we have to guard against is the mixing of two methods, and so far as we are concerned the intrusion into our subject of philosophical speculation. Let us willingly and with our hearts do homage to "divine Philosophy," but let that homage be rendered outside the limits of our science. Let those who are so inclined, cross the frontier and philosophize; but to me it appears to be more conducive to progress that we should do our best to furnish professed philosophers with such facts relating to structure and function as may serve them as aids in the investigation of those deeper problems which concern man's relations to the past, the present, and the unknown future.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY PROF. SIR WILLIAM TURNER, M.B., LL.D., F.R.SS.L. & E., PRESIDENT OF THE SECTION.

TWENTY-SIX years have passed by since the British Association for the Advancement of Science last assembled in this city. Many of the incidents of that meeting are still fresh in my memory, the more vividly, perhaps, because it was the first meeting of the Association that I had attended. The weather, so important a factor in most of our functions, was dry and bright. The visitor, instead of being enshrouded in that canopy of mist and smoke which so often meets the traveller as he approaches your city, was greeted with light and sunshine. The cordial welcome and reception so freely granted by the community, and more especially the princely yet gracious hospitality exercised by the President, your eminent townsman, now Lord Armstrong, are all deeply imprinted on my memory. But, apart from these attractions, which added so much to the amenities of the occasion, the meeting was one of deep interest to all those Members and Associates who were engaged in biological study.

Lyell's famous book on the "Antiquity of Man" had been published shortly before. The essays on the "Origin of Species" by natural selection, by Charles Darwin and Alfred Russel Wallace, had appeared only five years earlier in the Journal of the Linnean Society, and in 1859 Darwin's treatise on the "Origin of Species," in which its illustrious author summarized the facts he had collected and the conclusions at which he had arrived, had been published. Although no President of the British Association had up to that time given his adhesion to the new theory, yet it was clear that men were beginning to see, in many instances perhaps only dimly, how the theory of evolution by natural selection was destined to work a remarkable change, amounting almost to a revolution, in our conceptions of biological questions generally, and their applicability to the study of man.

At that time Anthropology had not assumed so definite a position in the work of the Association as it now possesses. Neither a Department nor a Section was devoted to it, and the subjects which it embraces were scattered abroad, either in the Department of Anatomy and Physiology, in the Section of Geography and Ethnology, in that of Geology, or in that of Statistics. It is true that a vigorous attempt was made about that time to give it a more independent position, but it was not until the Association met in Nottingham, in 1866, that it was assigned a definite Department, and at the Montreal meeting, in 1884, Anthropology assumed the dignity of a Section.

But although the youngest Section of the Association, the Science of Man is not the youngest of the sciences. Long before the British Association came into existence, Man, in his physical, racial, geological, and psychological aspects, had been studied by hosts of able and industrious inquirers. All that the Association has done in establishing a special Section of Anthropological Science has been to bring together, as it were, into a single focus all those workers who apply themselves to the study of man in his various aspects.

As presiding over the proceedings of the Section on this occasion, it is a part of my duty to open its public business with an address. For me, as doubtless for many of those who have preceded me in this honourable office, one's mind has been somewhat exercised in the choice of a subject. In a branch of biological science so vast as Anthropology, in which the room for selection is so ample, the difficulty of making a choice is perhaps still further increased. As a professional anatomist, whose life's work it has been to study the structure of the human body in its normal aspects, to inquire into the variations which it exhibits in different individuals, and to compare its structure with that of various forms of animal life, it at first occurred to me that an address on the physical characteristics of some of the races of men would be appropriate. But further consideration led me to think that such a subject would be too technical for a general audience, and that it might perhaps be productive of greater interest on the part of my auditors if I selected a topic which, whilst strictly scientific in all its bearings, yet appeals more distinctly to the popular mind, and is now attracting attention. Hence I have chosen the subject of Heredity, by which I mean that special property through which the peculiarities of an organism are transmitted to its descendants throughout successive generations, so that the offspring, in their main features, resemble their parents.

The subject of Heredity, if I may say so, is in the air at the present time. The journals and magazines, both scientific and literary, are continually discussing it, and valuable treatises on the subject are appearing at frequent intervals. But though so important a topic of existing scientific thought and speculation, it is by no means a new subject, and certain of its aspects were under discussion so far back as the time of Aristotle. The prominence which it has assumed of late years is in connection with its bearing on the Darwinian Theory of Natural Selection, and, consequently, biologists generally have had their attention directed to it. But in its relations to Man, his structure, functions, and diseases, it has long occupied a prominent position in the minds of anatomists, physiologists, and physicians. That certain diseases, for example, are hereditary was recognized by Hippocrates, who stated generally that hereditary diseases are difficult to remove, and the influence which the hereditary transmission of disease exercises upon the duration of life is the subject of a chapter in numerous works on practical medicine, and forms an important element in the valuation of lives for life insurance.

The first aspect of the question which has to be determined is whether any physical basis can be found for Heredity. Is there any evidence that the two parents contribute each a portion of its substance to the production of the offspring so that a physical continuity is established between successive generations? The careful study, especially during the last few years, of the development of a number of species of animals mostly but not exclusively among the Invertebrata, by various observers, of whom I may especially name Bütschli, Fol, E. Van Beneden, and Hertwig, has established the important fact that the young animal arises by the fusion within the egg or germ-cell of an extremely minute particle derived from the male parent with an almost equally minute particle derived from the germ-cell produced by the female parent. These particles are technically termed in the former case the *male pronucleus*, in the latter the *female pronucleus*, and the body formed by their fusion is called the *segmentation nucleus*. These nuclei are so small that it seems almost a contradiction in terms to speak of their magnitude; rather one might say their minimitude, for it requires the higher powers of the best microscopes to see them and follow out the process of conjugation. But notwithstanding their extreme minuteness, the pronuclei and the segmentation nucleus are complex both in chemical and molecular structure. From the segmentation nucleus produced by the fusion of the pronuclei with each other, and from corresponding changes which occur in the protoplasm of the egg which surrounds it, other cells arise by a process of division, and these in their turn also multiply by division. These cells arrange themselves in course of time into layers which are termed the germinal or embryonic layers. From these layers arise all the tissues and organs of the body, both in its embryonic and adult stages of life. The starting-point of each individual organism—*i.e.* of each new generation—is therefore the segmentation nucleus. Every cell in the adult body is derived by descent from that nucleus through repeated division. As the segmentation nucleus is formed by the fusion of material derived from both parents, a physical continuity is established between parents and offspring. But this physical continuity carries with it certain properties which cause the offspring to reproduce, not only the bodily configuration of the parent, but other characters. In the case of Man we find along with the family likeness in form and features a correspondence in temperament and disposition, in the habits and mode of life, and sometimes in the tendency to particular diseases. This transmission of characters from parent to offspring is summarized in the well-known expression that "like begets like," and it rests upon a physical basis.

The size of the particles which are derived from the parents, called the male and female pronuclei, the potentiality of which is so utterly out of proportion to their bulk, is almost inconceivably small when compared with the magnitude of the adult body. Further, by the continual process of division of the cells, the substance of the segmentation nucleus is diffused throughout the body of the new individual produced through its influence, so that each cell contains but an infinitesimal particle of it. The parental dilution, if I may so say, is so attenuated as to surpass the imagination of even the most credulous believer in the attenuation of drugs by dilution. And yet these particles are sufficient to stamp the characters of the parents, of the grandparents, and of still more remote ancestors on the offspring, and to preserve them throughout life, notwithstanding the constant changes to which the cells forming the tissues and organs of the body are subjected in connection with their use and nutrition. So marvellous, indeed, is the whole process, that even the exact contributions to recent knowledge on the fusion of the two pronuclei, instead of diminishing our wonder, have intensified the force of the expression "*magnum hereditatis mysterium.*"

In considering the question of how new individuals are produced, one must keep in mind that it is not every cell in the body which can act as a centre of reproduction for a new generation, but that certain cells, which we name germ-cells and sperm-cells, are set aside for that purpose. These cells, destined for the production of the next generation, form but a small proportion of the body of the animal in which they are situated. They are, as a rule, marked off from the rest of the cells of its body at an early period of development. The exact stage at which they become specially differentiated for reproductive purposes varies, however, in different organisms. In some organisms, as is said by Balbiani to be the case in *Chironomus*, they apparently become isolated before the formation of the germinal layers is completed; but, as a rule, their appearance is later, and in the higher organisms most not until the development of the body is relatively much more advanced.

The germ-cells after their isolation take no part in the growth of the organism in which they arise, and their chief association with the other cells of its body is that certain of the latter are of service in their nutrition. The problem, therefore, for consideration is the mode in which these germ or reproductive cells become influenced, so that after being isolated from the cells which make up the bulk of the body of the parent they can transmit to the offspring the characters of the parent organism. Various speculations and theories have been advanced by way of explanation. The well-known theory of Pangenesis, which Charles Darwin with characteristic moderation put forward as merely a provisional hypothesis, assumes that *gemmules* are thrown off from each different cell or unit throughout the body which retain the characters of the cells from which they spring; that the gemmules aggregate themselves either to form or to become included within the reproductive cells; and that in this manner they and the characters which they convey are capable of being transmitted in a dormant state to successive generations, and to reproduce in them the likeness of their parents, grandparents, and still older ancestors.

In 1872, and four years afterwards, in 1876, Mr. Francis Galton published most suggestive papers on Kinship and Heredity (Proc. Roy. Soc. Lond., 1872, and Journ. Anthrop. Inst, vol. v., 1876). In the latter of these papers he developed the idea that "the sum-total of the germs, gemmules, or whatever they may be called," which are to be found in the newly fertilized ovum, constitute a *stirp*, or root; that the germs which make up the stirp consist of two groups—the one which develops into the bodily structure of the individual, and which constitutes, therefore, the personal structure; the other, which remains latent in the individual, and forms, as it were, an undeveloped residuum; that it is from these latent or residual germs that the sexual elements intended for producing the next generation are derived, and that these germs exercise a predominance in matters of heredity; further, that the cells which make up the personal structure of the body of the individual exercise only in a very faint degree any influence on the reproductive cells, so that any modifications acquired by the individual are barely, if at all, inherited by the offspring.

Subsequent to the publication of Mr. Galton's essays, valuable contributions to the subject of Heredity have been made by Profs. Brooks, Jaeger, Naegeli, Nussbaum, Weismann, and others. Prof. Weismann's theory of Heredity embodies the same fundamental idea as that propounded by Mr. Galton; but as he has employed in its elucidation a phraseology which is more in harmony with that generally used by biologists, it has had more immediate attention given to it. As Weismann's essays have, during the present year, been translated for and published by the Clarendon Press (Oxford, 1889), under the editorial superintendence of Messrs. Poulton, Schönland, and Shipley, they are now readily accessible to all English readers.

Weismann asks the fundamental question, "How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?" He at once discards the theory of pangenesis, and states that in his belief the germ-cell, so far as its essential and characteristic substance is concerned, is not derived at all from the body of the individual in which it is produced, but directly from the parent germ-cell from which the individual has also arisen. He calls his theory the *continuity of the germ-plasm*, and he bases it upon the supposition that in each individual a portion of the specific germ-plasm derived from the germ-cell of the parent is not used up in the construction of the body of that individual, but is reserved unchanged for the formation of the germ-cells of the succeeding generation. Thus, like Mr. Galton, he recognizes that in the stirp or germ there are two classes of cells destined for entirely distinct purposes: the one for the development of the *soma* or body of the individual, which class he calls the *somatic* cells; the other for the perpetuation of the species, *i.e.* for reproduction.

In further exposition of his theory Weismann goes on to say, as the process of fertilization is attended by a conjugation of the nuclei of the reproductive cells—the pronuclei referred to in an earlier part of this address—that the nuclear substance must be the sole bearer of hereditary tendencies. The two uniting nuclei would contain the germ-plasms of the parents, and this germ-plasm also would contain that of the grandparents as well as that of all previous generations.

To make these somewhat abstract propositions a little more clear, I have devised the following graphic mode of representation:—

Let the capital letters A, B, C, D, &c., express a series of successive generations. Suppose A to be the starting-point, and to represent the somatic or personal structure of an individual; then *a* may stand for the reproductive cells, or germ-plasm, from which the offspring of A, viz. B, is produced. B, like A, has both a personal structure and reproductive cells or germ-plasm, the latter of which is represented by the letters *ab*, which are intended to show that whilst belonging to B they have a line of continuity with A. C stands for an individual of the third generation, in which the reproductive plasm is indicated by *abc*, to express that, though within the body of C, the germ-plasm is continuous with that of both *b* and *a*. D also contains the reproductive cells, *abcd*, which are continuous with the germ-plasm of the three preceding generations, and so on.

It follows, therefore, from this theory that the germ-plasm possesses throughout the same complex chemical and molecular structure, and that it would pass through the same stages when the conditions of development are the same, so that the same final product would arise. Each successive generation would have therefore an identical starting-point, so that an identical product would arise from all of them.

Weismann does not absolutely assert that an organism cannot exercise a modifying influence upon the germ-cells within it; yet he limits this influence to such slight effect as that which would arise from the nutrition and growth of the individual, and the reaction of the germ-cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, and arrangements of its molecular units. But he throws great doubt upon the existence of such a reaction, and he, more emphatically than Mr. Galton, argues against the idea that the cells which make up the somatic or personal structure of the individual exercise any influence on the reproductive cells. From his point of view the structural or other properties which characterize a family, a race, or a species are derived solely from the reproductive cells through continuity of their germ-plasm, and are not liable to modification by the action on them of the organs or tissues of the body of the individual organism in which they are situated. To return for one moment to my graphic illustration in elucidation of this part of the theory. The cells which make up the personal structure of A or B would exercise no effect upon the character of the reproductive cells *a* or *ab* contained within them. These latter would not be modified or changed in their properties by the action of the individual organism A or B. The individual B would be in hereditary descent, not from A + *a*, but only from *a*, with which its germ-plasma *ab* would be continuous, and through which the properties of the family, race, or species would be transmitted to C, and so on to other successive generations.

The central idea of Heredity is permanency; that like begets like, or, as Mr. Galton more fitly puts it, that "like *tends* to produce like." But though the offspring conform with their parents in all their main characteristics, yet, as everyone knows, the child is not absolutely like its parents, but possesses its own character, its own individuality. It is easy for anyone to recognize that differences exist amongst men when he compares one individual with another; but it is equally easy for those who make a special study of animals to recognize individual differences in them also. Thus a pigeon or canary fancier distinguishes without fail the various birds in his flock, and a shepherd knows every sheep under his charge. But the anatomist tells us that these differences are more than superficial—that they also pervade the internal structure of the body. In a paper which I read to the meeting of this Association in Birmingham so long ago as 1865,[1] after relating a series of instances of variation in structure observed in the dissections of a number of human bodies, I summarized my conclusion as follows: "Hence, in the development of each individual, a morphological specialization occurs both in internal structure and external form by which distinctive characters are conferred, so that each man's structural individuality is an expression of the sum of the individual variations of all the constituent parts of his frame."

As in that paper I was discussing the subject only in its morphological relations, I limited myself to that aspect of the question; but I might with equal propriety have also extended my conclusion to other aspects of man's nature.

Intimately associated, therefore, with the conception of Heredity—that is, the transmission of characters common to both parent and offspring—is that of Variability—that is, the appearance in an organism of certain characters which are unlike those possessed by its parents. Heredity, therefore, may be defined as the perpetuation of the like; Variability, as the production of the unlike.

And now we may ask, Is it possible to offer any feasible explanation of the mode in which variations in organic structure take their rise in the course of development of an individual organism? Anything that one may say on this head is of course a matter of speculation, but certain facts may be adduced as offering a basis for the construction of an hypothesis, and on this matter Prof. Weismann makes a number of ingenious suggestions.

Prior to the conjugation of the male and female pronuclei to form the segmentation nucleus a portion of the germ-plasm is extruded from the egg to form what are called the *polar bodies*. Various theories have been advanced to account for the significance of this curious phenomenon. Weismann explains it on the hypothesis that a reduction of the number of ancestral germ-plasms in the nucleus of the egg is a necessary preparation for fertilization and for the development of the young animal. He supposes that by the expulsion of the polar bodies one-half the number of ancestral germ-plasms is removed, and that the original bulk is restored by the addition of the male pronucleus to that which remains. As precisely corresponding molecules of this plasm need not be expelled from each ovum, similar ancestral plasms are not retained in each case; so that diversities would arise even in the same generation and between the offspring of the same parents.

Minute though the segmentation nucleus is, yet microscopic research has shown that it is not a homogeneous structureless body, but is built up of different parts. Most noteworthy are the presence of extremely delicate threads or fibrils, called the *chromatin filaments*, which are either coiled on each other, or intersect to form a network-like arrangement. In the meshes of this network a viscous—and, so far as we yet know, structureless—substance is situated. Before the process of division begins in the segmentation nucleus these filaments swell up and then proceed to arrange themselves at first into one and then into two star-like figures before the actual division of the nucleus takes place.[1] It is obvious, therefore, that the molecules which enter into the formation of the segmentation nucleus can move within its substance, and can undergo a readjustment in size and form and position. But this readjustment of material is, without doubt, not limited to those relatively coarse particles which can be seen and examined under the microscope, but applies to the entire molecular structure of the segmentation nucleus. Now it must be remembered that the cells of the embryo from which all the tissues and organs of the adult body are derived are themselves descendants of the segmentation nucleus, and they will doubtless inherit from it both the power of transmitting definite characters and a certain capacity for readjustment both of their constituent materials and the relative positions which they may assume towards each other. One might conceive, therefore, that if in a succession of organisms derived from common ancestors the molecular particles were to be of the same composition and to arrange themselves in the segmentation nucleus and in the cells derived from it on the same lines, these successive generations would be alike; but if the lines of adjustment and the molecular constitution were to vary in the different generations, then the products would not be quite the same. Variations in structure, and to some extent also in the construction of parts, would arise, and the unlike would be produced.

In this connection it is also to be kept in mind that in the higher organisms, and, indeed, in multicellular organisms generally, an individual is derived, not from one parent only, but from two parents. Weismann emphasizes this combination as the cause of the production of variations and the transmission of hereditary individual characters. If the proportion of the particles derived from each parent and the forces which they exercise were precisely the same in any individual case, then one could conceive that the product would be a mean of the components provided by the two parents. But if one parent were to contribute a larger proportion than the other to the formation of a particular organism, then the balance would be disturbed, the offspring in its character would incline more to one parent than to the other, according to the proportion contributed by each, and a greater scope for the production of variations would be provided. These differences would be increased in number in the course of generations, owing to new combinations of individual characters arising in each generation.

As long as the variations which are produced in an organism are collectively within a certain limitation, they are merely individual variations, and express the range within which such an organism, though exhibiting differences from its neighbours, may yet be classed along with them in the same species. It is in this sense that I have discussed the term Variability up to the present stage of this address. Thus all those varieties of mankind which, on account of differences in the colour of the skin, we speak of as the white, black, yellow races and red-skins are men, and they all belong to that species which the zoologists term *Homo sapiens*.

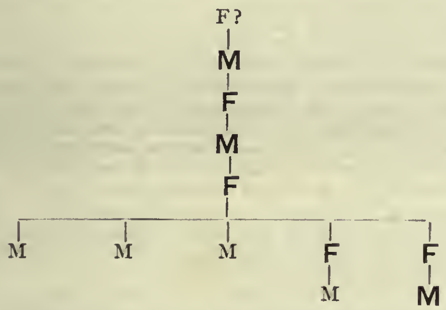
But the subject of Variability cannot, in the present state of science, be confined in its discussion to the production of individual variations within the limitations of a common species. Since Charles Darwin enunciated the proposition that favourable variations would tend to be preserved, and unfavourable ones to be destroyed, and that the result of this double action, by the accumulation of minute existing differences, would be the formation of new species by a process of natural selection, this subject has attained a much wider scope, has acquired increased importance, and has formed the basis of many ingenious speculations and hypotheses. As variations, when once they have arisen, may be hereditarily transmitted, the Darwinian theory might be defined as Heredity modified and influenced by Variability.

This is not the place to enter on a general discussion of the Darwinian theory, and even if it were, the time at our disposal

[1] Transactions of Sections, p. 111, 1865, and Trans. Roy. Soc. Edinburgh, vol. xxiv., 1865.

[1] The observations more especially of Flemming, E. Van Beneden, Strasburger, and Carnoy may be referred to in connection with the changes which take place in nuclei prior to and in connection with their division.

would not admit of it. But there are some aspects of the theory which would need to be referred to in connection with the subject now before us. It may be admitted that many variations which may arise in the development of an individual, and which are of service to that individual, would tend to be preserved and perpetuated in its offspring by hereditary transmission. But it is also without question that variations which are of no service, and, indeed, are detrimental, to the individual in which they occur, are also capable of being hereditarily transmitted. This statement is amply borne out in the study of those important defects in bodily structure which pathologists group together under the name of Congenital Malformations. I do not require to go into much detail on this head, or to cite cases in which the congenital defect can only be exposed by dissection, but may refer, by way of illustration, to one or two examples in which the defect is visible on the surface of the body. The commonest form of malformation the hereditary transmission of which has been proved is where an increase in the number of digits on the hands or feet, or on both, occurs in certain families, numerous instances of which have now been put on record. But in other families there is an hereditary tendency to a diminution in the number of digits or to a defect in the development of those existing. I may give an illustration which occurred in the family of one of my pupils, the deformity in which consisted in a shortening or imperfect growth of the metacarpal bone of the ring finger of the left hand, so that the length of that finger was much below the normal. This family defect was traceable throughout six generations, and perhaps even in a seventh, and was, as a rule, transmitted alternately from the males to the females of the family (*Journ. Anat. and Phys.*, vol. xviii. p. 463)—

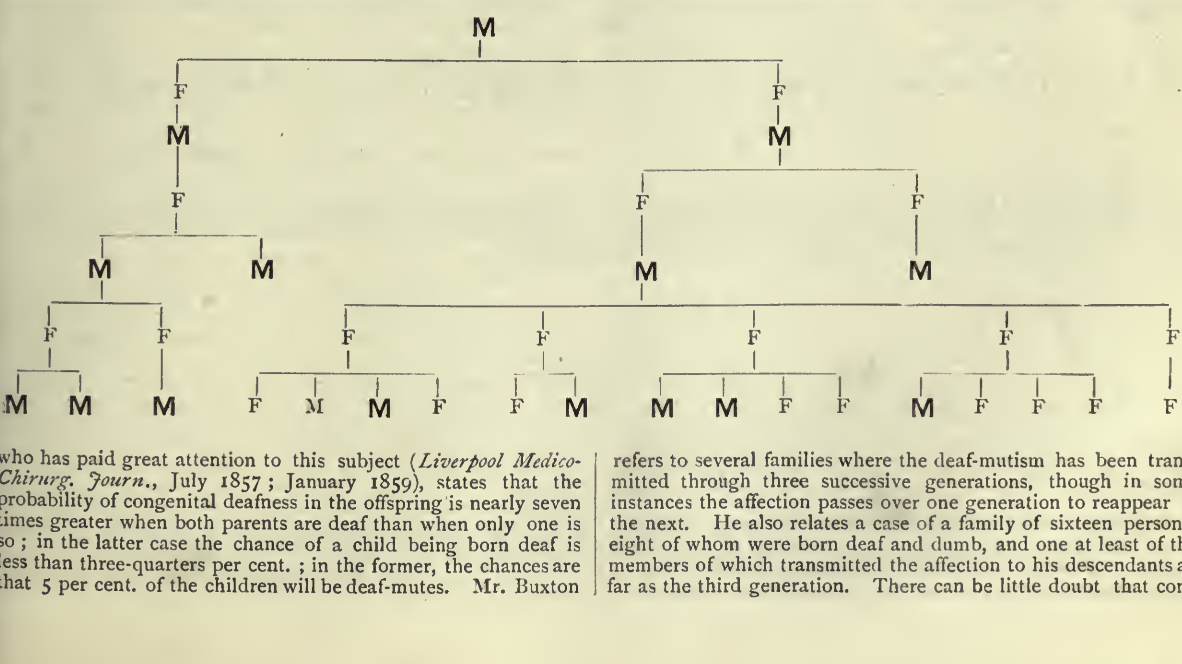


In this and the following diagrams M stands for male, F for female, whilst the block type (**M** or **F**) marks the individual or generation in which the variation occurred.

Another noticeable deformity which is known to be hereditary in some families, and which may be familiar to some of my auditors, is that of imperfect development of the upper lip and roof of the mouth, technically known as hare-lip and cleft palate.

These examples illustrate what may be called the coarser kinds of hereditary deformity, where the redundancies or defects in parts of the body are so gross as at once to attract attention. But modifications or variations in structure that can be transmitted from parent to offspring are by no means limited to changes which can be detected by the naked eye. They are sometimes so minute as to be determined rather by the modifications which they occasion in the function of the organ than by the ready recognition of structural variations. One of the most interesting of these is the affection known as Daltonism, or colour-blindness, which has distinctly been shown to be hereditary, and which is due, apparently in the majority of cases, to a defect in the development of the retina, or of the nerve of sight which ends in it, though in some instances they may be occasioned by defective development of the brain itself. Dr. Horner has related a most interesting family history (cited in "Die Allgemeine Pathologie," by Dr. Edwin Klebs, Jena, 1887), in which the colour-blindness was traced through seven generations. In this family the males were the persons affected, though the peculiarity was transmitted through the females, who themselves remained unaffected. The family tree showed that in the sixth generation seven mothers had children. Their sons, collectively nine in number, were all colour-blind with the exception of one son, while none of their nine daughters showed the hereditary defect. (See diagram below.)

The eye is not the only organ of sense which exhibits a tendency to the production of hereditary congenital defects. The ear is similarly affected, and intimately associated with congenital deafness is an inability to speak articulately, which occasions the condition termed Deaf-mutism. Statisticians have given some attention to this subject, both as regards its relative frequency and its hereditary character. The writer of the article "Vital Statistics," in the Report of the Irish Census Commissioners during the decades ending 1851, 1861, 1871, has discussed at some length the subject of congenital deaf-mutism, and has produced a mass of evidence which proves that it is often hereditarily transmitted. In the Census Report for 1871 (vol. lxxii. Part II., "Report on the Status of Disease," p. 1, 1873), 3297 persons were returned as belonging to this class, and in 393 cases the previous or collateral branches of the family were also mute. In 211 of these the condition was transmitted through the father; in 182 through the mother. In 2579 cases there was one deaf-mute in a family; in 379 instances, two; in 191 families, three; in 53, four; in 21, five; in 5, six; and in each of two families no fewer than seven deaf-mutes were born of the same parents. In one of these two families neither hereditary predisposition nor any other probable physiological or pathological reason was assigned to account for the peculiarity, but in the other family the parents were first cousins. Mr. David Buxton,



who has paid great attention to this subject (*Liverpool Medico-Chirurg. Journ.*, July 1857; January 1859), states that the probability of congenital deafness in the offspring is nearly seven times greater when both parents are deaf than when only one is so; in the latter case the chance of a child being born deaf is less than three-quarters per cent.; in the former, the chances are that 5 per cent. of the children will be deaf-mutes. Mr. Buxton refers to several families where the deaf-mutism has been transmitted through three successive generations, though in some instances the affection passes over one generation to reappear in the next. He also relates a case of a family of sixteen persons, eight of whom were born deaf and dumb, and one at least of the members of which transmitted the affection to his descendants as far as the third generation. There can be little doubt that congenital deaf-mutism, in the great majority of instances, is associated with a defective development, and therefore a structural variation of the organ of hearing, though in some cases, perhaps, the defect may be in the development of the brain itself.

Although a sufficient number of cases has now been put on record to prove that in some families one or other kind of congenital deformity may be hereditarily transmitted, yet I do not wish it to be supposed that congenital malformations may not arise in individuals in whom no hereditary tendency can be traced. It is undoubtedly true that family histories are in many cases very defective, and frequently cannot be followed back for more than one, or, at the most, two generations; so that it is not unlikely that an hereditary predisposition may exist in many instances where it cannot be proved. Still, allowing even for a considerable proportion of such cases, a sufficient number will remain to warrant the statement that malformations or variations in structure which have not been displayed by their ancestors may arise in individuals belonging to a particular generation.

The variations which I have spoken of as congenital malformations arise, as a rule, before the time of birth, during the early development of the individual; but there is an important class of cases, in which the evidence for hereditary transmission is more or less strong, which may not exhibit their peculiarities until months, or even years, after the birth of the individual. This class is spoken of as hereditary diseases, and the structural and functional changes which they produce exercise most momentous influences. Sometimes these diseases may occasion changes in the tissues and organs of the body of considerable magnitude, but at other times the alteration is much more subtle, is molecular in its character, requires the microscope for its determination, or is even incapable of being recognized by that instrument.

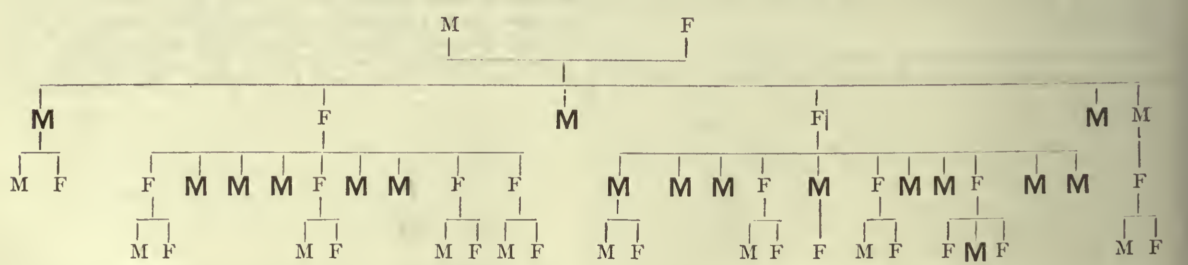
Had one been discussing the subject of hereditary disease twenty years ago, the first example probably that would have been adduced would have been tuberculosis, but the additions to our knowledge of late years throw some doubt upon its hereditary character. There can, of course, be no question that tubercular disease propagates itself in numerous families from generation to generation, and that such families show a special susceptibility or tendency to this disease in one or other of its forms. But whilst fully admitting the predisposition to it which exists in certain families, there is reason to think that the structural disease itself is not hereditarily transmitted, but that it is directly excited in each individual in whom it appears by a process of external infection due to the action of the tubercle bacillus. Still, if the disease itself be not inherited, a particular temperament which renders the constitution liable to be attacked by it is capable of hereditary transmission.

Sir James Paget,[1] when writing on the subject of cancer, gives statistics to show that about a quarter of the persons affected were aware of the existence of the same disease in other members of their family, and he cites particular instances in which cancer was present in two and even four generations. He had no doubt that the disease can be inherited—not, he says, that, strictly speaking, cancer or cancerous material is transmitted, but a tendency to the production of those conditions which will finally manifest themselves in a cancerous growth. The germ from the cancerous parent must be so far different from the normal as after the lapse of years to engender the cancerous condition.

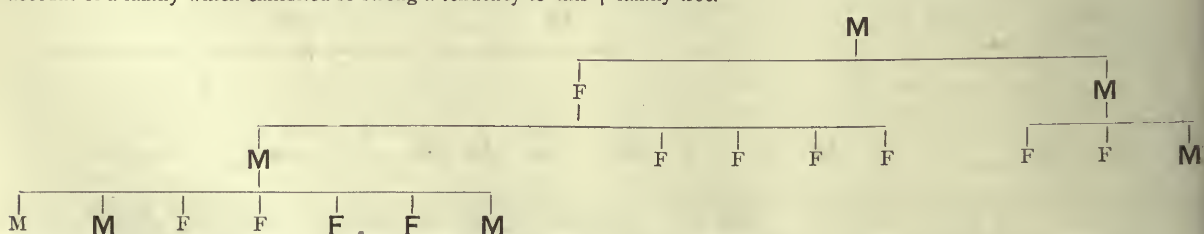
Heredity is also one of the most powerful factors in the production of those affections which we call gout and rheumatism. Sir Dyce Duckworth, the latest systematic writer on gout, states that in those families whose histories are the most complete and trustworthy the influence is strongly shown, and occurs in from 50 to 75 per cent. of the cases; further, that the children of gouty parents show signs of articular gout at an age when they have not assumed those habits of life and peculiarities of diet which are regarded as the exciting causes of the disease.

Some interesting and instructive family histories, in which the hereditary transmission of a particular disease through several generations has been worked out, are recorded by Prof. Klebs in his "Allgemeine Pathologie." I may draw from these one or two additional illustrations. Some families exhibit a remarkable tendency to bleed when the surface of the body is injured or bruised, and the bleeding is stopped with difficulty. The hæmorrhagic tendency is not due to the state of the blood, but to a softening or degeneration of the walls of the blood-vessels, so that they are easily torn. In one family, the tree of which is here subjoined, this peculiarity showed itself in one generation in three out of four males; in the next generation, in thirteen out of fourteen males; whilst in the immediately succeeding generation only one out of nine males was affected; so that it would seem as if the tendency was fading away in it. It is remarkable that throughout the series, though the transmission of the affection went through the female members, they themselves remained free from it.

The bleeding family Mampel, recorded by Dr. Lossen.



Another illustration may be taken from the well-known disease of the eyeball called cataract. Dr. Appenzeller has given an account of a family which exhibited so strong a tendency to this affection that the males were affected in four generations, though the females did not entirely escape, as is shown in the subjoined family tree.



In neither of these families can it be said that the structural lesion itself is transmitted, but that the tendency or predisposition to produce it is inherited. The germ-plasm, therefore, in these individuals must have been so modified from the normal as to carry with it certain peculiarities, and to induce the particular form of disease which showed itself in each family.

[1] "Lectures on Surgical Pathology," third edition, revised and edited by the author and W. Turner (London, 1870).

In connection with the tendency to the transmissibility of either congenital malformations or diseases, consanguinity in the parents, although by no means a constant occurrence, is a factor which in many cases must be taken into consideration.[1] If we could conceive both parents to be physiologically perfect, then it may be presumed that the offspring would be so also; but if there be a departure in one parent from the plane of physiological perfection, then it may safely be assumed that either the immediate offspring or a succeeding generation will display a corresponding departure in a greater or less degree. Should both parents be physiologically imperfect, we may expect the imperfections if they are of a like nature to be intensified in the children. It is in this respect, therefore, that the risk of consanguineous marriages arises, for no family can lay claim to physiological perfection.

When we speak of tendencies, susceptibilities, proclivities, or predisposition to the transmission of characters, whether they be normal or pathological, we employ terms which undoubtedly have a certain vagueness. We are as yet quite unable to recognize, by observation alone, in the germ-plasm any structural change which would enable us to say that a particular tendency or susceptibility will be manifested in an organism derived from it. We can only determine this by following out the life-history of the individual. Still it is not the less true that these terms express a something of the importance of which we are all conscious. So far as Man is concerned, the evidence in favour of a tendency to the transmission of both structural and functional modifications which are either of dis-service, or positively injurious, or both, is quite as capable of proof as that for the transmission of characters which are likely to be of service. Hence useless as well as useful characters may be selected and transmitted hereditarily.

I have dwelt somewhat at length on the transmissibility of useless characters, for it is an aspect of the subject which more especially presents itself to the notice of the pathologist and physician; and little, if at all, to that of those naturalists whose studies are almost exclusively directed to the examination of organisms in their normal condition. But when we look at Man, his diseases form so large a factor in his life that they and the effects which they produce cannot be ignored in the study of his nature.

Much has been said and written during the last few years of the transmission from parents to offspring of characters which have been "acquired" by the parent, so that I cannot altogether omit some reference to this subject. It will conduce to one's clearness of perception of this much-discussed question if one defines at the outset in what sense the term "acquired characters" is employed; and it is the more advisable that this should be done, as the expression has not always been used with the same signification. This term may be used in a wide or in a more restricted sense. In its wider meaning it may cover all the characters which make their first appearance in an individual, and which are not found in its parents, in whatever way they have arisen—

(1) Whether their origin be due to such molecular changes in the germ-plasm as may be called spontaneous, leading to such an alteration in its character as may produce a new variation; or,

(2) Whether their origin be accidental, or due to habits, or to the nature of the surroundings, such as climate, food, &c.

Prof. Weismann has pointed out with great force the necessity of distinguishing between these two kinds of "acquired characters," and he has suggested two terms the employment of which may keep before us how important it is that these different modes of origin should be recognized. Characters which are produced in the germ-plasm itself by natural selection, and all other characters which result from this latter cause, he names *blastogenic*. He further maintains that all blastogenic characters can be transmitted; and in this conclusion, doubtless, most persons will agree with him. On the other hand, he uses the term *somatogenic* to express those characters which first appear in the body itself, and which follow from the reaction of the *soma* under direct external influences. He includes under this head the effects of mutilation, the changes which follow from increased or diminished performance of function, those directly due to nutrition, and any of the other direct external influences which act upon the body. He further maintains that the somatogenic characters are not capable of transmission from parent to offspring, and he suggests that in future discussions on this subject the term "acquired characters" should be restricted to those which are somatogenic.

Thus one might say that blastogenic characters arising in the germ would be acquired in the individual by the action of the germ upon the soma; so that if we return again to the graphic illustration previously employed, the germ-plasm represented by the small italic letters *abcd* would act upon the soma represented by the capital letters A, B, C, D. Somatogenic characters, again, arising in the soma, would be acquired by the action of the soma A, B, C, D, upon the contained germ-plasm *abcd*. But whether those acquired characters expressed by the term somatogenic can or can not be transmitted has been fruitful of discussion.

That the transmission of characters so acquired can take place is the foundation of the theory of Lamarck, who imagined that the gradual transformation of species was due to a change in the structure of a part of an organism under the influence of new conditions of life, and that such modifications could be transmitted to the offspring. It was also regarded as of importance by Charles Darwin, who stated[1] that all the changes of corporeal structure and mental power cannot be exclusively attributed to the natural selection of such variations as are often called spontaneous, but that great value must be given to the inherited effects of use and disuse, some also to the modification in the direct and prolonged action of changed conditions of life, also to occasional reversions of structure. Herbert Spencer believes[2] that the natural selection of favourable varieties is not in itself sufficient to account for the whole of organic evolution. He attaches a greater importance than Darwin did to the share of use and disuse in the transmission of variations. He believes that the inheritance of functionally produced modifications of structure takes place universally, and that as the modification of structure by function is a *vera causa* as regards the individual, it is unreasonable to suppose that it leaves no traces in posterity.

On the other hand, there are very eminent authorities who contend that the somatogenic acquired characters are not transmissible from parent to offspring. Mr. Francis Galton, for example, gives a very qualified assent to this proposition. Prof. His, of Leipzig, doubts its validity. Prof. Weismann says that there is no proof of it. Mr. Alfred Russel Wallace, in his most recent work,[3] considers that the direct action of the environment, even if we admit that its effects on the individual are transmitted by inheritance, are so small in comparison with the amount of spontaneous variation of every part of the organism that they must be quite over-shadowed by the latter. Whatever other causes, he says, have been at work, natural selection is supreme to an extent which even Darwin himself hesitated to claim for it.

There is thus a conflict of opinion amongst the authorities who have given probably the most thought to the consideration of this question. It may appear, therefore, to be both rash and presumptuous on my part to offer an opinion on this subject. I should, indeed, have been slow to do so had I not thought that there were some aspects of the question which seemed not to have been sufficiently considered in its discussion.

In the first place, I would, however, express my agreement with much that has been said by Prof. Weismann on the want of sufficient evidence to justify the statement that a mutilation which has affected a parent can be transmitted to the offspring. It is, I suppose, within the range of knowledge of most of us that children born of parents who have lost an eye, an arm, or a leg, come into the world with the full complement of eyes and limbs. The mutilation of the parent has not affected the offspring; and one would, indeed, scarcely expect to find that such gross visible losses of parts as take place when a limb is removed by an accident or a surgical operation should be repeated in the offspring. But a similar remark is also applicable to such minor mutilations as scars, the transmission of which to the offspring, though it has been stoutly contended for by some, yet seems not to be supported by sufficiently definite instances.

I should search for illustrations of the transmission of somatogenic characters in the more subtle processes which affect living organisms, rather than those which are produced by violence

[1] I may especially refer for a discussion of this subject to an admirable essay, by Sir Arthur Mitchell, K.C.B., "On Blood Relationship in Marriage considered in its Influence upon the Offspring."

[1] Preface to second edition of "Descent of Man," 1885; also "Origin of Species," first edition.

[2] "Factors of Organic Evolution," *Nineteenth Century*, 1886.

[3] "Darwinism," p. 443 (London, 1889).

and accident. I shall take as my example certain facts which are well known to those engaged in the breeding of farm-stock or of other animals that are of utility to or are specially cultivated by man.

I do not refer to the influence on the offspring of impressions made on the senses and nervous system of the mother, the first statement of the effects of which we find in the book of Genesis, where Jacob set peeled rods before the flocks in order to influence the colour and markings of their young; though I may state that I have heard agriculturists relate instances from their own experience which they regarded as bearing out the view that impressions acting through the mother do influence her offspring. But I refer to what is an axiom with those who breed any particular kind of stock, that to keep the strain pure, there must be no admixture with stock of another blood. For example, if a shorthorned cow has a calf by a Highland sire, that calf, of course, exhibits characters which are those of both its parents. But future calves which the same cow may have when their sires have been of the shorthorned blood, may, in addition to shorthorn characters, have others which are not shorthorned but Highland. The most noteworthy instance of this transmission of characters acquired from one sire through the same mother to her offspring by other sires is that given in the often-quoted experiment by a former Lord Morton.[1] An Arabian mare in his possession produced a hybrid the sire of which was a quagga, and the young one was marked by zebra-like stripes. But the same Arabian had subsequently two foals, the sire of which was an Arab horse, and these also showed some zebra-like markings. How, then, did these markings characteristic of a very different animal arise in these foals, both parents of which were Arabians? I can imagine it being said that this was a case of reversion to a very remote striped ancestor, common alike to the horse and the quagga. But, to my mind, no such far-fetched and hypothetical explanation is necessary. The cause of the appearance of the stripes seems to me to be much nearer and more obvious. I believe that the mother had acquired, during her prolonged gestation with the hybrid, the power of transmitting quagga-like characters from it, owing to the interchange of material which had taken place between them in connection with the nutrition of the young one. For it must be kept in mind that in placental mammals an interchange of material takes place in opposite directions, from the young to the mother as well as from the mother to the young.[2] In this way the germ-plasm of the mother, belonging to ova which had not yet matured, had become modified whilst still lodged in the ovary. This acquired modification had influenced her future offspring, derived from that germ-plasm, so that they in their turn, though in a more diluted form, exhibited zebra-like markings. If this explanation be correct, then we have an illustration of the germ-plasm having been directly influenced by the soma, and of somatogenic acquired characters having been transmitted.

But there are other facts to show that the isolation of the germ-cells or germ-plasm from the soma cells is not so universal as might at the first glance be supposed. Weismann himself admits that in the Hydroids the germ-plasm is present in a very finely divided, and therefore invisible, state, in certain somatic cells in the beginning of embryonic development, and that it is then transmitted through innumerable cell generations to those remote individuals of the colony in which sexual products are formed. The eminent botanist Prof. Sachs states that in the true mosses almost any of the cells of the roots, leaves, and shoot axes may form new shoots and give rise to independent living plants. Plants which produce flowers and fruit may also be raised from the leaves of the *Begonia*. I may also refer to what is more or less familiar to everybody, that the tuber of the potato can give rise to a plant which bears flowers and fruit. Now in all these cases the germ-plasm is not collected in a definite receptacle isolated from the soma, but is diffused through the cells of the leaves of the *Begonia* or amidst those of the tuber of the potato, and the propagation of the potato may take place through the tuber for several generations without the necessity of having to recur to the fruit for seed. It seems difficult, therefore, to understand why, in such cases, the nutritive processes which affect and modify the soma cells should not also react upon the germ-plasm, which, as Weismann admits, is so intimately associated with them.

[1] Philosophical Transactions, 1881; also Darwin's "Animals and Plants under Domestication," first edition, vol. i. p. 403, 1868.

[2] See, for example, Essays by Profs. Harvey and Gusserow and Mr. Savory; also my "Lectures on the Comparative Anatomy of the Placenta" (Edinburgh, 1876).

Those who uphold the view that characters acquired by the soma cannot be transmitted from parents to offspring undoubtedly draw so large a cheque on the bank of hypothesis that one finds it difficult, if not impossible, to honour it. Let us consider for one moment all that is involved in the acceptance of this theory, and apply it in the first instance to Man. On the supposition that all mankind have been derived from common ancestors through the continuity of the germ-plasm, and that this plasm has undergone no modification from the *persona* or *soma* of the succession of individuals through whom it has been transmitted, it would follow that the primordial human germ-plasm must have contained within itself an extraordinary potentiality of development—a potentiality so varied that all those multiform variations in physical structure, tendency to disease, temperament, and other characters and dispositions which have been exhibited by all the races and varieties of men who either now inhabit or at any period in the world's history have inhabited the earth, must have been included in it. But if we are to accept the theory of Natural Selection, as giving a valid explanation of the origin of new species, then the non-transmissibility of somatogenic acquired characters has a much more far-reaching significance. For if all the organisms, whether vegetable, animal, or human, which have lived upon the earth have arisen by a more or less continuous process of evolution from one or even several simple cellular organisms, it will follow, as a logical necessity of the theory, that these simple organisms must have contained in their molecular constitution a potentiality of evolution into higher and more complex forms of life, through the production of variations, without the intermediation of any external force or influence acting directly upon the soma. Further, this must have endured throughout a succession of countless individual forms and species, extending over we know not how many thousands of years, and through the various geological and climatic changes which have affected the globe.

The power of producing these variations would therefore, on this theory, have been from the beginning innate to the germ-plasm, and uninfluenced in any way by its surroundings. Variations would have arisen spontaneously in it, and, for anything that we know, as it were by accident, and without a definite purport or object. But whether such variations would be of service or dis-service could not be ascertained until after their appearance in the soma had subjected them to the test of the conditions of life and the environment.

Let us now glance at the other side of the question. All biologists will, I suppose, accept the proposition that the individual soma is influenced or modified by its environment or surroundings. Now, if on the basis of this proposition the theory be grafted that modifications or variations thus produced are capable of so affecting the germ-plasm of the individual in whom the variation arises as to be transmitted to its offspring—and I have already given cases in point—then such variations might be perpetuated. If the modification is of service, then presumably it will add to the vitability of the individual, and through the interaction between the soma and the germ-plasm, in connection with their respective nutritive changes, will so affect the latter as to lead to its being transmitted to the offspring. From this point of view the environment would, as it were, determine and regulate the nature of those variations which are to become hereditary, and the possibility of variations arising which are likely to prove useful becomes greater than on the theory that the soma exercises no influence on the germ-plasm. Hence I am unable to accept the proposition that somatogenic characters are not transmitted, and I cannot but think that they form an important factor in the production of hereditary characters.

To reject the influence which the use and disuse of parts may exercise both on the individual and on his offspring is like looking at an object with only a single eye. The morphological aspect of organic structure is undoubtedly of fundamental importance. But it should not be forgotten that tissues and organs, in addition to their subjection to the principles of development and descent, have to discharge certain specific purposes and functions, and that structural modifications arise in them in correlation with the uses to which they are put, so as to adapt them to perform modified duties. It may be difficult to assign the exact value which physiological adaptation can exercise in the perpetuation of variations. If the habit or external condition which has produced a variation continues to be practised, then, in all probability, the variation would be intensified in successive generations. But should the habit cease or the external condition be changed, then, although the variation might continue to be for a time perpetuated by descent, it would probably become less strongly marked and perhaps ultimately disappear. One could also conceive that the introduction of a new habit or external condition the effect of which would be to produce a variation in a direction different from that which had originally been acquired, would tend to neutralize the influence of descent in the transmission of the older character.

By accepting the theory that somatogenic characters are transmitted we obtain a more ready explanation how men belonging to a race living in one climate or part of the globe can adapt themselves to a climate of a different kind. On the theory of the non-transmissibility of these acquired characters, long periods of years would have to elapse before the process of adaptation could be effected. The weaker examples, on this theory, would have had to have died out, and the racial variety would require to have been produced by the selection of variations arising slowly, and requiring one knows not how many hundreds or thousands of years to produce a race which could adapt itself to its new environment. We know, however, that this process of the dying out of the weakest and the selection of the strongest is not necessary to produce a race which possesses well-recognizable physical characters. For most of us can, I think, distinguish the nationality of a citizen of the United States by his personal appearance, without being under the necessity of waiting to hear his speech and intonation

It may perhaps be thought that, in selecting the subject of Heredity for my address, and in treating it, as I have to a large extent done, in its general biological aspects, I have infringed upon the province of Section D. But I am not prepared to admit that any such encroachment has been made. Man is a living organism, with a physical structure which discharges a variety of functions, and both structure and functions correspond in many respects, though with characteristic differences, with those which are found in animals. The study of his physical frame cannot therefore be separated from that of other living organisms, and the processes which take place in the one must also be investigated in the other. Hence we require, in the special consideration of the physical framework of Man, to give due weight to those general features of structure and functions which he shares in common with other living organisms. But whatever may have been the origin of his frame, whether by evolution from some animal form or otherwise, we can scarcely expect it ever to attain any greater perfection than it at present possesses.

The physical aspect of the question, although of vast importance and interest, yet by no means covers the whole ground of Man's nature, for in him we recognize the presence of an element beyond and above his animal framework.

Man is also endowed with a spiritual nature. He possesses a conscious responsibility which enables him to control his animal nature, to exercise a discriminating power over his actions, and which places him on a far higher and altogether different platform than that occupied by the beasts which perish. The kind of evolution which we are to hope and strive for in him is the perfecting of this spiritual nature, so that the standard of the whole human race may be elevated and brought into more harmonious relation with that which is holy and divine.

REPORTS.

Report (Second) of the Committee appointed for the purpose of Collecting Information as to the Disappearance of Native Plants from their Local Habitats. Prof. Hillhouse, Secretary.

As intimated at the close of the Report for 1887,[1] the Committee has given its attention in the first instance to Scotland, and appends hereto such portion of the materials placed at its disposal as, for any reason, it considers desirable to publish. It has excluded a considerable number of plants of little interest, and especially such as the records show to be recent introductions, casuals, escapes, &c., the loss of which is only a return, therefore, to an earlier, but still recent, state. There is little doubt that the list, even thus restricted, will be considerably amplified hereafter.

The plants recorded are numbered in accordance with the "London Catalogue," eighth edition, in which the distribution census of each plant will be found. Nearly all of the records are on the authority of some competent botanist resident in the locality, and whose initials, or some distinguishing initials, are appended. As has been pointed out by more than one correspondent, scarce plants occasionally well-nigh disappear in particular seasons, and hence the records of other than frequent visitors are not fully reliable.

[1] The Committee was unable to report in 1888, having lapsed by accident.

The attention of botanists is particularly drawn to the records under the numbers 52, 264, 374, 406, 570, 575, 687, 910, 932, 993, 1018, 1020, 1478, 1695, and 1772, as giving examples of divers ways, often very curious and interesting, in which plants can become extinct.

The attention of the Committee's correspondents has been, in the main, confined to complete or threatened extinction; but in addition to this there is a general consensus of opinion that the rarer and more conspicuous Alpine plants are less abundant than they used to be. Amongst the localities specially mentioned are Clova and Ben Lawers; such plants (in addition to those given in the list) as *Saxifraga cernua*, *Alsine rubella*, *Gentiana nivalis*, &c., are notably less frequent than twenty years ago. Strange rumours have been communicated to the Committee as to the disappearance of plants from accessible habitats within the range of some of the deer "forests," but it is unable to verify these statements. Most of the correspondents agree, however, that the injudicious action of botanists themselves, and of botanical exchange clubs, has been a potent factor in the changes which have taken place. It is too often forgotten that the very rarity of a plant is the sign, and in great degree also the measure, of the acuteness of its struggle for existence, and that when a plant is in a state of unstable equilibrium with its environment, a small disturbance may have disproportionately great effects.

It will be observed that the "dealer" and "collector" figure largely, especially in connection with the disappearance of ferns. Thus one of the correspondents indicates (and offers to name) a dealer who has extirpated, or well-nigh extirpated, a considerable number of species in the district of Dumfries, and whose conduct he had brought under the notice of the local Natural History Society, of which the correspondent is Secretary. "He had also removed and sold almost all of the plants of *Nymphæa alba* from the lochs of this district before discovery; but now, I am happy to say, he is forbidden access to any estate in this district under penalty of prosecution for trespass." The attention of Natural History Societies may well be drawn to this case, as it happily illustrates at the same time one phase of the disease and a cure.

"Summer visitors" do not appear to be directly responsible for much damage, as their wanderings are probably over too restricted an area to produce much effect. There is no doubt, however, that they provide the larger portion of the customers of the "collector," and so are indirectly answerable for his ravages. The temptation to bring home some rare and beautiful fern, like *Aspidium* (*Polystichum*) *Lonchitis*, as a relic of a northern trip, is too great to be resisted, though something may possibly be done by persuading tourists that equally good plants, taken up with all proper care, and at a season when transplanting is not dangerous, can be obtained from any great fern nursery, for a price which is practically lower, often much lower, than that charged upon some Highland railway platform or roadside.

The Committee feels, however, that neither local dealers nor their customers are as a rule amenable to any ordinary appeal or to sentimental considerations, and would suggest therefore that the local Natural History Societies or Field Clubs should keep careful guard over any rare plants to be found within their respective spheres of action, and by appeal to the owner, or in other preferable way, should endeavour to effect their preservation. At the same time, many correspondents draw attention to the insertion by gardening periodicals of the advertisements of collecting dealers, and express the hope that the amount of revenue derived from these advertisements is not so great as to negative the possibility that the gardening journals may be induced, by discontinuing their insertion, to strike a heavy blow at a process which is depriving many districts of our land of one of their chief natural beauties.

39 *Trollius europæus*, L. Extinct in Mid-Aberdeen, &c. (W. W. and J. M.).

52. *Nymphæa alba*, L. Almost extirpated from lochs in the district round Dumfries by a dealer (J. W.). Has disappeared from the district of Birnie, near Elgin, by drainage (G. and T. A.).

58. *Meconopsis cambrica*, Vig. Believed to be extirpated from banks of Water of Leith and Currie, Midlothian (G. A. P.).

59. *Glaucium flavum*, Crantz. Recorded in 1776 for sea-shore at Bay of Nigg, near Aberdeen, but not since 1800 (J. W. H. T.). Found sixty years ago at Montrose Links; not now (R. B.).

184. *Dianthus Armeria*, L. Occurred, though not abundantly, in rough pasture near Glencarse Station, Perthshire; has been entirely destroyed through the cultivation of the ground (F. B. W.). This was one of its most northern stations.

207. *Lychnis viscaria*, L. Blackford Hill, Midlothian; now very rare (G. A. P.). Arthur's Seat, Edinburgh; supposed to be extirpated (G. A. P.),

208. *Lychnis alpina*. Is now becoming rare in its habitats on Clova Mountains (G. A. P.).

263. *Hypericum perforatum*, L. Formerly grew plentifully near Cromarty Nursery, but has ceased to exist, as the ground is now used for agricultural purposes (T. A.). This was one of its most northern stations.

264. *Hypericum quadrangulum*, L. Has wholly disappeared from the vicinity of Fortrose, Ross-shire, having been eaten by cattle or trodden down (T. A.). This was one of its most northern stations.

368. *Lotus pilosus*, Beeke. Extinct round Alford, Mid-Aberdeenshire, from cultivation (W. W.).

374. *Oxytropis uralensis*, D.C. Grew in abundance near Invergordon, Ross-shire, but on one occasion the medical man of the town saw a man digging it up with a trowel, and it is now extinct (T. A.).

375. *Oxytropis campestris*, D.C. Rocks at Bradoony, Clova; now very rare; extirpated from all accessible parts of the rocks (G. A. P.).

406. *Lathyrus niger*, Wimm. Has well-nigh disappeared from its station at Killiecrankie Pass owing to the late guide to the Pass showing it to all tourists. An appeal to the proprietor might save the rest of the specimens, of which very few stations exist (F. B. W.).

501. *Agrimonia Eupatoria*, L. Becoming very scarce in Glen Urquhart, Inverness-shire (Gr.). This was one of its most northern stations.

525. *Pyrus Aria*, Sm. One specimen only (? *P. fennica*, L.) known in Arran; now lost through injury (G. A. P.). Lost also from one or two other stations on the Western Highlands, and now very rare in Scotland.

570. *Sedum reflexum*, L. Found freely on a wall at Birnie, Elgin; disappeared through repairs (G.). Not native.

575. *Drosera anglica*, Huds. Extinct in Kincardine (M.). Extinct round Alford, Mid-Aberdeen, through drainage (W. W.).

577. *Hippuris vulgaris*, L. Extinct round Alford, Mid-Aberdeen, but still appears on the borders of Banffshire.

611. *Eryngium maritimum*, L. Found in the early part of the century on the sandy coast at St Cyrus, near Montrose, and at St. Fergus, Peterhead, but extinct in both localities from unknown causes (J. W. H. T. and R. B.).

687. *Linnæa borealis*, Gronov. Has been cleared from near Dingwall, Ross-shire, owing to the wood in which it grew having been cut down and the ground cultivated (T. A.). Formerly grew at Kingsmills, but has been destroyed through cultivation (G. A., *fide* T. A.). These are two of the most northern British stations.

812. *Silybum Marianum*, Gaertn. Has gone from the rocks near Tarbet-ness Lighthouse, Ross-shire (D.). This plant is very rare in Scotland.

887. *Lactuca* (*Mulgedium*) *alpinum*. This plant was found (probably abnormally) on the Coreen Hills at about 700 feet, but is now extinct (W. W.).

910. *Vaccinium Oxycoccos*, L. Formerly grew in a piece of mossy land on the uplands north of Mealfourvouny, a hill of Old Red Sandstone conglomerate above 3000 feet, but whether the plants were of recent introduction or last survivors, they have disappeared (Gr.).

926. *Phyllodoce taxifolia*, Salisb. (*Menziesia cærulea*). The only British habitat of this plant is the Sow of Athol, and it has now been nearly extirpated, for sale (K. and F. B. W.). The habitat is within sight of a gamekeeper's house, so that its protection would be easy if the Duke of Athol, the owner, could be moved to that effect.

929. *Pyrola media*, Sw. Has disappeared from White Hills, Colvend, Kirkcudbrightshire, through sheep grazing (J. M. A.).

932. *Moneses grandiflora*, Salisb. (*Pyrola uniflora*, L.). Extirpated from Woodhead Hill, Traqueer, Dumfriesshire (J. W.). Once not uncommon on the Muirhead of Scone; now very rare, from extirpation by botanists and others (F. B. W.). Formerly abundant within 4 miles of Forres; now extirpated; also from the wood at Brodie, near Forres, from the wood being cut down, and from Coul Woods, near Strathpeffer. It is also disappearing from Rothiemurchen, in this case from the rapacity of collectors (K.).

945. *Primula scotica*, Hook. Marsh near Edinburgh, Pentland Hills; practically extirpated (G. A. P.).

984. *Asperugo procumbens*, L. Has not been found for some years near the village of Balnahuish, on the Dornoch Firth (D.). This was its most northern station.

993. *Mertensia maritima*, Don. Shingle at Bay of Nigg, Aberdeen; almost extirpated from shingle being removed to form concrete blocks used in building a pier some years ago (J. W. H. T.).

1006. *Echium vulgare*, L. Nearly extinct, through cultivation, in the Black Isle, between Inverness and Fortrose, Ross-shire (T. A.).

1018. *Atropa Belladonna*, L. Has disappeared from Renlop Abbey, near Birnie, by extraction, on account of the accidents it had caused (G.). Has not been seen for some years at the Old Kutt, near Ganlude (T. A.). This eliminates two of the few Scottish stations.

1020. *Hyoscyamus niger*, L. Appeared in two or three places in the neighbourhood of Avoch, a fishing village on the Moray Firth, but disappeared in a few years. Informant "thinks it would come up again if the ground were deeply trenched. Some years ago an old elm was blown down and the root blasted, and for two succeeding summers *H. niger* grew luxuriantly in the hole caused by the tearing up of the root of the tree" (S. R., *fide* T. A.).

1092. *Utricularia vulgaris*, and 1094, *U. minor*, L. Extinct in Central Aberdeen (J. M. and W. W.).

1161. *Ajuga pyramidalis*. Has disappeared from In. Achilty, Dingwall, Ross-shire (T. A.).

1424. *Paris quadrifolia*, L. There is one station near the town of Inverness; nearly extinct, through the publicity of its habitat, this being one of the chief resorts of the population (T. A.). This is one of its most northern stations.

1431. *Juncus balticus*, Willd. Loch of Park, and Links north of Aberdeen; never plentiful, and not seen for some years. Cause of disappearance doubtful (J. W. H. T.).

1457. *Sparganium ramosum*, Curtis; *S. simplex*, Huds.; *S. affine*, Sch.; and *S. minimum*, Fr. All apparently extinct in Mid-Aberdeen (W. W.).

1478. *Scheuchzeria palustris*, L. The only Scottish station for this plant, a marsh near Methven (known botanically as "Methven bog"), has been lost; perhaps from the outlet becoming blocked, so that more water collected than the plant could stand, but more probably from the settlement there of a large colony of about 3000 black-headed gulls, the result being the destruction of all but the rankest vegetation (chiefly *Carex ampullacea*). Very careful searching during the last three years has failed to show a trace of the plant (F. B. W.).

1590. *Carex limosa*, L. Has disappeared from Maxwell-town Loch, Kirkcudbrightshire, through drainage (J. M. A.).

1695. *Melica uniflora*, Retz. Is not now found by the side of the burn at Golspie, Sutherland, probably from the hollow, caused by the upturned stool of a large tree which has been blown over, draining the spot where it grew (J.). This was its most northern Scottish station.

1766. *Cryptogramme crispa*, R. Br. (Parsley fern). Extirpated from several localities in the vicinity of Dumfries (J. W.). Abundant thirty years ago on an ancient hill-fortress near Brechin; now extirpated by traders (R. B.).

1772. *Asplenium viride*, Huds. Nearly extinct in district of Black Isle, between Inverness and Fortrose, through drainage and cultivation (T. A.). Has been extirpated from its old habitats in Glen Urquhart, Inverness-shire, by an itinerant fern-collector who squatted in the neighbourhood and took all he could find; but new habitats have been discovered (Gr.).

1773. *Asplenium Trichomanes*, L. Not now found in the woods of Knockespock Clatt, Mid-Aberdeen (W. W.).

1776. *Asplenium germanicum*, Weiss. Nearly eradicated from Stenton Rock, near Dunkeld (F. B. W.).

1777. *Asplenium septentrionale*, Hull. Probably extirpated, or nearly so, from Arthur's Seat, Edinburgh (G. A. P.). Nearly eradicated from Stenton Rock, near Dunkeld (F. B. W.).

1779. *Athyrium alpestre*, Milde. Now very rare in Clova Mountains, and mostly in accessible places (G. A. P.).

1781. *Ceterach officinarum*, Desv. Almost extirpated from Orchard-town Tower, Kirkcudbrightshire, by fern-hunters (J. M. A.). Used to grow on the walls of Drumlanrig Castle, one of the seats of the Duke of Buccleuch, Dumfriesshire, but not now found there (T. A.).

1782. *Scolopendrium vulgare*, Symons. Almost extirpated from several places in Kirkcudbrightshire by fern-hunters (J. M. A.). Extirpated from several places in the vicinity of Dumfries (J. W.) On the burns falling into Loch Ness there is now only one in which this plant is to be found, owing to the ravages of the itinerant fern-collector referred to under 1772. It still exists, however, in inaccessible stations (Gr.).

1783. *Woodsia ilvensis*, R. Br. Well-nigh extirpated by fern-hunters from the Moffat district (J. W.).

1787. *Cystopteris montana*. This plant, though not at present really uncommon round Aberfeldy, will not improbably be made very scarce by fern-collectors. It has disappeared altogether from one of the stations in which it was first found in Britain (F. B. W.).

1788. *Polystichum Lonchitis*, Roth. Almost extinct on Meal-fourvouny Mountain, Inverness-shire, through the action of fern-collectors, and especially of the one referred to under 1772 and 1782 (Gr.). Has been cleared from the Raven's Rock, near Strathpeffer, Dingwall, Ross-shire, by summer visitors (T. A.). Was plentiful near Castleton, Braemar, formerly, but the guides learned that they could sell it at a shilling a plant, and it is now difficult to get (T. A.).

1803. *Phegopteris* (*Polypodium*) *Robertiana*, A. Br.; *Polypodium calcareum*, Sm. Once abundant in the *débris* of an old limestone quarry near Aberfeldy, but now nearly eradicated. Fern-hunting visitors and tourists are largely to blame for this, but the destruction has been completed by persons who collect ferns for sale. That the species is not altogether lost in the district is, however, shown by the fact that a few weeks ago a local fern-hunter was offering plants for sale, and at the same time plants of 1787, *Cystopteris montana* (F. B. W., July, 1887).

1806. *Osmunda regalis*, L. Has disappeared from Ballingear Glen, New Galloway, and from other places, as Colvend, through the ravages of fern-hunters (J. M. A.). Extirpated from several localities in the vicinity of Dumfries (J. W.). Has entirely disappeared from Loch of Park, and nearly from the cliffs south of Aberdeen, in both of which localities it was formerly plentiful. Fern-collectors are mainly responsible (J. W. H. T.).

1809. *Botrychium Lunaria*, Sw. Formerly very local in the Pentlands; now extirpated (G. A. P.).

1818. *Equisetum hyemale*, L. Extinct in Mid-Aberdeen (J. M.).

Report of the Committee appointed for the purpose of co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis. Mr. Buchan, Secretary.

The work of carrying on the observations hourly, by night as well as day, has been carried on by Mr. Omond and his assistants during the year with the same enthusiasm and unbroken continuity as in time past; and the five daily observations in connection with the Ben Nevis Observatory have been made at Fort William by Mr. Livingston with the greatest regularity and care.

As in the previous year, the state of the health of the observers, occasioned by their continuous residence at the top of the mountain, where exercise in the open air is practically impossible during the greater part of the year, rendered it again necessary to give them relief during the winter and spring. The services of Mr. Drysdale were again secured for six months; Mr. R. C. Mossman, the Society's observer for Edinburgh, gave his services as observer for six weeks in April and May; and Mr. McDonald, Edinburgh, has given a month's service as observer in July and August of this year. Messrs. Omond and Rankin, during the time they were relieved from the work of the Observatory, took part in the work of the office of the Scottish Meteorological Society, and gave material assistance, more particularly in the reduction, preparation for press, and discussion of the Ben Nevis observations.

The photographing of clouds and other meteorological phenomena has been actively prosecuted at the Observatory, and results of considerable interest and importance have been already obtained. Selections from the photographs were exhibited by the Scottish Meteorological Society and by the Royal Meteorological Society during the winter session. Of these photographs four are submitted with this Report—viz. (1) a photograph of St. Elmo's fire; (2) a cloud photographed at midnight of June last year; (3) a remarkably fine photograph of a cloud, partly made up of flattened masses, which is occasionally formed in mountainous districts; and (4) photographs of crystals on the Observatory and instruments outside.

Mr. Rankin has extended and amplified his investigation of the cases of St. Elmo's fire recorded at the Observatory; and the results, which are interesting and suggestive, have been published in the Journ. Scot. Meteor. Soc.

Mr. Omond has entered on an investigation of the relations of the wind direction on the top of Ben Nevis to the sea-level isobaric of the district at the time, and to the storms advancing on the Atlantic towards North-Western Europe, as shown on the daily weather charts of the northern hemisphere published by the Meteorological Institutes of Germany and Denmark.

This is properly only the commencement of a large discussion of the Ben Nevis observations in some of their more practical aspects, which will be undertaken and pushed forward next year on the plan referred to in last year's Report, as rapidly as the means at the disposal of the Directors of the Observatory will admit.

This season (1889) the snow disappeared from the summit of the mountain in the middle of May, being about a month earlier than in any previous year, and seven weeks earlier than in 1885; and during the month of June the spring near the Observatory, and about 60 feet lower down, frequently ran dry, so that for some time water had to be carried on horseback a distance of two and a half miles.

The Directors have had under consideration a proposed systematic observation of the numbers of dust particles in the atmosphere with the instrument recently invented by Mr. John Aitken, and they are of opinion that the Ben Nevis Observatory is the best place for making the observations in the most satisfactory manner. Mr. Aitken will himself superintend the construction of the two instruments which are required, and will see to the placing of the stationary one in the Observatory, and its connections with the atmosphere outside, in suitable positions, and give directions as to the portable one designed as a check instrument, and for observations made at various distances from the Observatory. Application has been made for a grant from the Government Research Fund to aid in carrying on this novel and important research.

Mr. Aitken recently visited the Observatory, and ten observations of the numbers of dust particles on the top of the mountain were made by Mr. Omond and himself, with the results that the numbers per cubic centimetre rose from 350 at noon to 500 at 3 p.m. This result of the first observation is interesting and suggestive. The purest air previously obtained by Mr. Aitken anywhere was on the Ayrshire coast, and on that occasion the numbers were 1260 per cubic centimetre. It may be also observed that the numbers on Ben Nevis rose from noon to 3 p.m., the observations being made at the time of the day when aërial currents from lower levels ascend along the heated sides of the mountain to the Observatory.

In January last the Directors accepted an offer from the Meteorological Council that, on being satisfied that provision had been made for the maintenance of a Low Level Observatory at Fort William, they would supply and erect in the Observatory the self-registering instruments and otherwise complete the ordinary outfit of meteorological instruments, and make an annual grant of £250 towards its maintenance, and also continue the grant of £100 yearly under the present arrangement.

Since last Report, the Directors have received a legacy of £500 bequeathed to the Observatory, by the late Mr. R. M. Smith, who was one of the Directors; and a grant of £1000 from the Association of the Edinburgh International Exhibition of 1886 from the Surplus Fund of the Exhibition. A suitable site for the Low Level Observatory was procured in Fort William, and plans of the buildings were prepared by their architects, Messrs. Sydney Mitchell and Wilson, which were submitted to the Directors and the Meteorological Council, and approved of. The building is now well advanced, and it is expected that the Observatory will be opened towards the end of the autumn.

The Directors of the Observatory and your Committee in their successive Reports from 1884 insisted on the absolute necessity of combining the double observation for all forecasting purposes, and inquiries in connection therewith; in other words, of combining with the observation at the top of Ben Nevis that made at the same instant near sea-level at Fort William. With the opening of the Low Level Observatory in November will commence a new era in the work of the Ben Nevis Observatory. It will then be possible, by the double set of horizontal meteorological gradients and vertical meteorological gradients thus obtainable, to examine more fully and rigorously the atmospheric changes which precede, accompany, and follow the passage across these islands of the cyclones and anticyclones of North-Western Europe.

The minimum temperature on Ben Nevis for the year was 7°·2, being the lowest yet observed since the Observatory was opened in 1883. The maximum was 61°·1 in June, which closely agrees with the maxima of previous years, except that of 1887, which rose to 67°·0. It is also to be noted that so late as September temperature rose to 57°·6.

The registrations of the sunshine recorder showed 970 hours of sunshine during the year, the smallest number of hours for any month being 8 for November, and the largest 250 in June, being nearly half the possible sunshine. The number of hours for the four years now observed, beginning with 1885, were 680, 576, 898, and 970. The contrast of the sunshine of 1886 with that of 1888 is thus very striking.

The amount of rainfall for the year was 132·46 inches, the month of least rainfall, 3·76 inches, being June, and of greatest, 20·60 inches, being November. The number of days on which precipitation was *nil*, or less than the hundredth of an inch, was 118. The number of rainless days for the last three years have been 159, 128, and 118. From all the observations yet made, it is seen that a fall, equalling at least 1·00 a day, has occurred on an average of one day in nine.

Atmospheric pressure was this year again above the annual average, the mean at sea-level being 29·889, or 0·055 higher. The lowest mean at the Observatory, 25·035 inches, occurred in March, and the highest, 25·590 inches, in September; the difference being 0·555 inch. At sea-level at Fort William the extreme monthly means were 29·636 inches in November, and 30·132 in September; the difference being 0·496 inch.

NOTES.

MR. GRIESBACH, of the Geological Survey of India, shortly proceeds to Beluchistan to exploit for coal; and Mr. Oldham, also of the Geological Survey, is also going to Beluchistan to investigate and report upon oil fields which are believed to exist there.

THE Iron and Steel Institute has assembled this year in Paris at the rooms of the National Industry Encouragement Society, and its first sitting was held on the 24th inst., under the presidency of Sir J. Kitson. The paper which attracted most attention on the first day was one by M. Schneider, of Creuzot, and M. Hersent, ex-President of the French Civil Engineers' Society, on the Channel Bridge, which gave an elaborate account of the scheme. The route chosen as the line, stretching over the shallowest parts of the Channel and connecting the shores where closest to each other, commences at a point near Cape Gris Nez, passes over the Colbart and Varne banks, and terminates near Folkestone. The Colbart and Varne banks are situated near the centre of the Channel, about 6 kilometres apart, the depth of the water at that point not exceeding 7 or 8 metres at low water, and they are separated from each other by a depression about 25 to 27 metres deep. Between the Varne and the British coast the depth does not exceed 29 metres, but near Colbart the bottom sinks somewhat abruptly down to 40 metres. It then attains 55 metres about midway across, when it begins gradually to rise. In these parts the chief difficulties would be encountered in laying the foundations. The result of repeated experiments is that the ground is found to be sufficiently solid to support very extensive works, and the borings lately made in connection with the proposed tunnel have confirmed preceding experiments as to the position and nature of the bottom as published by M. de Gamond. The metal proposed to be used is steel. The amount of metal and machinery to be provided would represent an aggregate weight of about 1,000,000 tons. The spans of metal would be 500 metres in length across the Channel, supported on columns resting at different depths on the bottom of the sea. A rough calculation gives 380,000,000 francs for masonry supports, and 480,000,000 francs for the metallic superstructure—in all, 860,000,000 francs, or £34,400,000. The time required for the undertaking was fixed at about ten years.

THE eleventh Congress of the Sanitary Institute was opened at Worcester on the 24th inst. In connection with the Congress an exhibition of sanitary appliances and apparatus is being held at the Skating Rink, where also lectures on cookery are given by Dr. Strange. The Presidential address was delivered by Mr. G. W. Hastings, M.P., and referred mainly to recent legislation affecting sanitary science.

THE International Oriental Congress, which was held this year during the first and second weeks of the present month, in Stockholm and Christiania, was well attended, and was especially noticeable for the enlightened and warm interest taken in the proceedings by the King. Representatives of Oriental learning from the chief countries were His Majesty's personal guests, the members of the Congress present were on several occasions specially entertained by him, and in other marked ways the King showed his desire to honour science and learning in the persons of the assembled Oriental scholars. The *Times* is the only one of the English daily papers in which the proceedings have been followed regularly, and in the last letter on the subject, its Correspondent, who has been far from a prophet of smooth things in reference to all the proceedings, says that "this eighth International Oriental Congress was favoured above all its predecessors by the right royal splendour with which the ruler of the two countries entertained his guests, by the warm interest which the citizens took in the foreign *savants*, by the care and kindly forethought with which all the arrangements for our comfort had been planned and were carried out, and last (not least) by the grand and lovely natural features of the places which the members visited. Perhaps at future Congresses care will be taken that there be less of empty Oriental parade, by which no palpable literary object can be gained, and that greater facilities be given for placing without delay within the reach of members an abstract of the proceedings in each Section. However, in the face of such boundless hospitality and such personal sacrifices on the part of our hosts, it would be ungracious were we to take exception to what are after all but small matters of detail."

A LARGE number of papers of great philological and general interest were read, as will be readily gathered from the following list of the Sections, with their respective Presidents and Vice-Presidents:—Section I. Modern Semitic: Presidents—Baron Kremer, of Vienna; M. Schefer, of Paris; M. de Goeje, of Leyden. Section II. Ancient Semitic: President—M. Fehr, of Stockholm; Vice-Presidents—M. Chivolson, of St. Petersburg; M. Oppert, of Paris. Section III.: Presidents—M. Max Müller, of Oxford; M. Weber, of Berlin; M. Spiegel, of Erlangen. Section IV.: President—Brugsch Pasha; Vice-Presidents—M. Lieblein, M. Reinisch. Section V.: President—M. Schlegel, of Leyden; Vice-President—M. Cordier, of Paris. Section VI.: President—M. Kern, of Leyden; Vice-President: Mr. R. N. Cust, of London.

A CORRESPONDENT sends us the following instance of "Science as she is wrote," which he thinks worth preserving. It is extracted from an eloquent description of the icebergs near the coast of Newfoundland, which appeared in the *Daily Telegraph* of September 17, and was signed "Edwin Arnold":—"The icebergs are unfortunately most to be expected in those summer months when alone the navigation is open. The first heats of the brief but hot Arctic sunshine set in rapid motion the glaciers of Labrador and Greenland. These vast storehouses of gathered and consolidated snow glide to the edge of the tremendous precipices of the Winter Lands, and, falling over them in monstrous masses, crash into the deep water with shocks which send thunder-peals through the still Polar air, and perturb the ocean far and near with rolling waves. Then, committed by this awful launch to the southward-going currents, the great broken glittering mass goes solemnly sailing away in the unwonted sunshine. As it floats, the water, warmer than the air, melts its lower portion gradually, and detached pieces also fall from the visible part, until equilibrium becomes destroyed, and the colossal block capsizes with a second shock, startling the ocean for leagues around."

We have received from the Mansion House a copy of the pamphlet relating to the Mansion House Fund for the Pasteur Institute. Besides a full report of the meeting held on July 1, it contains an excellent introduction describing the aims and needs of the fund, written by the Lord Mayor, and statistics of the work done by anti-rabic institutions in France and elsewhere. The last paragraph of the Lord Mayor's introduction is itself an ample justification of the appeal which he makes, for in it he reports that during July and August he sent over to Paris seventeen poor persons who had been bitten by mad dogs. There they have been treated free of charge, as usual by M. Pasteur. The Honorary Secretary to the Fund is Dr. Rueffer, 26 Torrington Square, London.

The syllabus of the eighth course of lectures and demonstrations for sanitary officers at the Sanitary Institute during the coming winter has been issued. The introductory lecture, on the general history, principles, and methods of hygiene, by Sir Edwin Chadwick, will be delivered on October 8, and the course will be continued every Tuesday and Friday at 8 p.m. until November 15. Amongst the lectures are: water supply, by Dr. Louis Parkes; drainage and construction, by Prof. H. Robinson; ventilation, by Sir Douglas Galton; sanitary appliances, by Prof. Corfield; scavenging, by Mr. Percy Boulnois; food, by Mr. Cassal; infectious diseases and methods of disinfection, by Mr. Shirley F. Murphy; general powers and duties of inspectors of nuisances, by Mr. J. F. J. Sykes; and sanitary law, by Mr. Wynter Blyth.

The carrier pigeon has just been turned to a curious use in Russia, according to the *Novoe Vremya*. It is to convey negatives of photographs taken in a balloon. The first experiment was made from the cupola of the Cathedral of Isaac, and the subject photographed was the Winter Palace. The plates were packed in envelopes impenetrable to the light, and then tied to the feet of the pigeons, who safely and quickly carried them to the station at Volkovo.

The current issue of the *Kew Bulletin* opens with a memorandum on the use of the flowers of *Calligonum* as an article of food in North-Western India. From a note from Mr. Duthie, of the Botanical Department of Northern India, it seems that the flowers of the *Calligonum polygonoides*, locally known as *phog*, are gathered and used by the poorer classes. They are either mixed with flour, in the proportion of a third *phog* to flour, or are eaten separately with salt and condiments, to which those who can afford it add a little glue. The flowers are swept up as they fall, and are kept for a night in a closed earthenware vessel, so as to fade. Sometimes they are kneaded up in the thin atta, about a fourth flowers to three-fourths atta, and baked in cakes and eaten. The flowers sent home have been analyzed by Prof. Church, who states that the chief peculiarity of these flowers, from a dietetic point of view, is their richness in nitrogenous compounds, and that there is rather a close resemblance in composition between *phog* and the seeds of the edible amaranths and buckwheats, only sugar replaces starch. There are also a short note from Dr. Ernst, of Caracas, Venezuela, on the earliest mention of coca, and a memorandum on the *Buazé* fibre, which the natives living around Lake Ngami use to make fishing-nets. The efforts which are being made to catalogue and publish the notices of Chinese plants scattered through botanical literature and to enumerate in systematic order the species of which specimens are to be found in the British Museum and in Kew, are described. Finally, there are two notes on vine cultivation and the Phylloxera, one being the substance of the report, made by Mr. Dyer in 1881, of the conclusions of the International Congress at Bordeax, which he attended as the representative of certain Colonial Governments; and the other a report on the vineyards of the Cape Colony, by M. Mouillefert, Professor of Viticulture in the French School of Agriculture at Grignon.

According to the Naples Correspondent of the *Daily News*, the scientific excursion to the volcanic regions of Italy, which commenced on the 14th inst., under the direction of Dr. H. J. Johnston-Lavis, of Naples, is exciting great interest. The affair is under the special patronage of Signor Boselli, the Minister of Public Instruction, of several Italian communes, and of the London and Italian Geological Societies. The general director is Dr. Johnston-Lavis, and the secretary in London is Dr. J. Fullerton. The visits to the various notable places will be personally conducted by Prof. Struver, of Rome; Prof. Silvestri, of Catania; Profs. Sacchi and Bassani, of Naples; Dr. Johnston-Lavis, and several others. The English, Belgians, and Italians who joined in the excursion were received at Naples, which was the starting-point, on the Sunday, by the Syndic of Naples, who also intends to give a banquet to the visitors, tickets for the theatres, and to show them other attentions during their visit to the city. Serious business commenced on the 16th inst., with a voyage to the Æolian Islands and Sicily the culminating point of this part of the programme being an ascent of Etna, which is fixed for the 29th inst. A special steamer or steam yacht will be either engaged or lent for this journey. The return to Naples will take place on the 30th inst. From the 1st to the 14th of October the head-quarters will be Naples. During this time excursions will be made to the Phlegiæan Fields, Vesuvius, the craters of Campania, the islands, and the coast towns of the Gulf, and visits paid to the sights of the city, the museums, while lectures, conversaziones, and garden parties will afford relaxation from the harder scientific work. On the 15th and 16th the volcanic groups of Monte Rocca-Monfina and the celebrated monastery of Monte Cassino will be visited, and from the 17th to the 29th Rome and its volcanic neighbourhood will be examined. Among the notable spots to be visited are Capo di Bove, Monte Tuscolo, Monte Porzio, Rocca-di-Papa, Monte Cavo, Lago di Albano, Nemi, Monte Mario, Bagno di Tivoli, Tivoli, Monte Cimmino, Monte Venere, and the crater of Vico, Frascati, and many famous villas. On the 30th of October the members will separate at Viterbo, going each their own way. The Minister of Public Instruction has accorded many facilities, such as reduced fares to the intending travellers, and the director and secretaries are using every effort to render the tour a complete success. Apart from the scientific interest of the excursion, it will afford an unexampled opportunity for becoming acquainted with some of the most beautiful and picturesque parts of Italy and Sicily.

In a Report presented to the Foreign Office by the British Consul at Florence, there is a very full account of the forests on the north-eastern boundary of Italy, which in that region are superintended by a large staff of officials. In the mountainous regions the maintenance of the forests is an absolute necessity, but, unfortunately, many slopes have become quite denuded through reckless cutting in the past. The actual extent of forest area has, however, increased since the sixteenth century, but energetic measures are now needed to prevent many of the woods deteriorating any further. Complaints are made by those who are anxious to preserve the forests that the peasants are not taught the value of them, and that in the elementary schools the principles of woodcraft and agriculture are never taught. Of the whole area under timber, the State owns only 3·42 per cent., while the *communes* possess 79·93 per cent., and private owners 16·63 per cent. As a rule the communal management is very reckless, and the forests have suffered so much that it has been seriously considered that the woods should be divided up amongst the peasants; but it is more than probable that this remedy would prove worse than the disease. The timber in the Cadore country is said to be the best in the world. Amongst the trees of the region are—the common Norway spruce, which flourishes at an altitude of 2400 metres above the level of the Adriatic, and grows to a height of about 30 metres; a variety of the Norwegian spruce, resembling the beech in its fibres, with harder wood, shorter leaves, and smaller cones than the common spruce; the common silver fir, which grows in the mountains 1500 metres above the Adriatic, and reaches a height of 25 metres; the common larch, the Scotch fir, the Mugho pine, the Swiss stone pine, the beech, and the walnut.

FROM the general results of the Swiss census of December 1, 1888, which have already been worked out, it seems that the total population is 2,934,055, against 2,846,102 in 1880. The German-speaking element increased from 2,030,792 in 1880 to 2,092,562, which, taking into account the normal growth of the population, was no relative increase, the proportion in both cases being precisely 71·3 per cent. of the whole. The French, on the other hand, increased from 608,007 to 637,940, which was also a relative increase of 21·4 to 21·7 per cent.; while the Italian declined actually as well as relatively, the numbers being 161,923 in 1880 and 156,602 in 1888, or 5·7 and 5·3 per cent. respectively. The decline of the Italians in the Cantons of Uri and Schwyz is explained by the return home of a large number of Italian workmen engaged in the St. Gothard Railway; but it is not so easy to explain why there is a large decrease in the Germans in the Cantons of Berne and Neuchâtel, while the French have increased. In general the French increase in Switzerland seems to be at the expense of the Germans, while the German element recovers its place at the expense of the Italian.

WE have received a "Guide to Technical and Commercial Education," drawn up by the executive Committee of the Dundee and District Association for the Promotion of Technical and Commercial Education. It is intended to fulfil one of the objects for which the Association was promoted, viz. "To draw up a syllabus for the district, in which shall be suggested such courses of education as shall be most suitable for particular trades; and further, to indicate (*a*) the number of years required for the complete education, (*b*) the total cost, and (*c*) the institutions in which the necessary instruction may be obtained." We draw special attention to this "Guide," as it cannot fail to be of the utmost use to similar Associations elsewhere, especially as it is drawn up with reference to the Science and Art examinations and those of the City Guilds. A definite order of study is suggested and recommended in a number of subjects, such as commerce, civil, mechanical, and electrical engineering, architecture, art industries, textiles, ship-building, gas manufacture, &c. The courses have evidently been compiled with great care and patience, and with the aid of practical men in the various subjects treated.

AMONGST the books to be published by Messrs. Crosby Lockwood and Son during the coming publishing season are:—"The Art of Paper Manufacture," by Alexander Watt; "A Hand-book on Modern Explosives," by M. Eissler; "Engineering Estimates, Costs, and Accounts," by a General Manager; "The Mechanical Engineer's Office Book," by Nelson Foley, second edition; "The Practical Engineer's Hand-book," by Walter S. Hutton, third edition; "Electric Light, its Production and Use," by J. W. Urquhart, third edition; "The Fields of Great Britain," a text-book of agriculture adapted to the Syllabus of the Science and Art Department, by Hugh Clements, second edition. And the following new editions in Weale's Rudimentary Scientific Series:—"Metallurgy of Iron," by H. Bauerman; "The Mineral Surveyor and Valuer's Complete Guide," by W. Lintern; "Stationary Engine Driving," by Michael Reynolds; "Irrigation and Water Supply," by Prof. John Scott.

MR. T. J. P. JODRELL, of Yeardsley, Cheshire, sometime of Stratton Street, London, whose death, as recently announced in the *Times*, took place on the 3rd inst., in his eighty-second year, was the founder of the Jodrell Fund, a capital sum of £6000 having been given by him to the Royal Society in the year 1876 for scientific purposes.

THE additions to the Zoological Society's Gardens during the past week include a White-fronted Lemur (*Lemur albifrons* ♂) from Madagascar, presented by Mr. C. O. Pelly; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. H. B. Wedlake; a Brown Bear (*Ursus arctus*) from Russia, presented by Mr. Frank Dugdale; a Crested Porcupine (*Hystrix cristata*) from Africa, presented by Mrs. Lucas-Shadwell; three African Lepidosirens (*Protopterus annectans*) from the River Gambia, West Africa, deposited; a Burchell's Zebra (*Equus burchelli* ♀), from South Africa, four Larger Tree Ducks (*Dendrocygna major*), three Indian Tree Ducks (*Dendrocygna javanica*) from India, a Tuberculated Iguana (*Iguana tuberculata*) from Brazil, purchased; a Red Kangaroo (*Macropus rufus* ♂), two Cockateels (*Calopsitta novæ-hollandiæ*), a Crested Pigeon (*Ocyphaps lophotes*), a Nicobar Pigeon (*Calænas nicobarica*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

COMET 1889 *e* (DAVIDSON).—The following ephemeris for Greenwich midnight for this object is in continuation of that given in NATURE for August 29 (p. 424):—

1889.	R.A. h. m. s.	Decl. ° ′	Log Δ.	Log *r*.	Brightness.
Sept. 29	17 14 19	32 6·5 N.	0·1635	0·1940	0·03
Oct. 3	17 21 53	32 38·5	0·1829	0·2064	0·02
7	17 29 28	33 8·2	0·2011	0·2186	0·02
11	17 37 7	33 36 1 N.	0·2182	0·2306	0·02

The brightness at discovery is taken as unity.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *SEPTEMBER* 29—*OCTOBER* 5.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 29

Sun rises, 5h. 59m.; souths, 11h. 50m. 11·7s.; daily decrease of southing, 19·5s.; sets, 17h. 41m.: right asc. on meridian, 12h. 23·9m.; decl. 2° 35′ S. Sidereal Time at Sunset, 18h. 16m.

Moon (at First Quarter October 2, 2h.) rises, 11h. 8m.; souths, 15h. 40m.; sets, 20h. 4m.: right asc. on meridian, 16h. 14·4m.; decl. 18° 29′ S.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	8 30	13 15	18 0	13 49·4	14 59 S.
Venus.....	2 44	9 46	16 48	10 19·9	11 18 N.
Mars......	2 49	9 51	16 53	10 24·8	11 18 N.
Jupiter....	13 35	17 27	21 19	18 1·6	23 30 S.
Saturn....	2 23	9 34	16 45	10 7·0	12 56 N.
Uranus...	7 22	12 46	18 10	13 19·8	7 48 S.
Neptune..	19 50*	3 39	11 28	4 11·2	19 24 N.

* Indicates that the rising is that of the preceding evening.

Oct.	h.	
1	11	Jupiter in conjunction with and 0° 39′ south of the Moon.
1	13	Venus in conjunction with and 0° 22′ south of Mars.
4	1	Mercury stationary.

Variable Stars.

Star.	R.A.	Decl.			h. m.	
	h. m.	° ′				
S Ceti	0 18·4	9 57 S.	Oct.	1,		*M*
U Cassiopeiæ	0 40·2	47 39 N.	,,	3,		*M*
U Cephei	0 52·5	81 17 N.	,,	5,	3 26	*m*
Algol	3 1·0	40 32 N.	,,	4,	3 45	*m*
λ Tauri	3 54·5	12 11 N.	,,	5,	0 59	*m*
U Boötis	14 49·2	18 9 N.	Sept.	30,		*M*
S Herculis	16 46·8	15 8 N.	,,	29,		*M*
U Ophiuchi	17 10·9	1 20 N.	,,	29,	20 52	*m*
			Oct.	4,	21 38	*m*
Y Sagittarii	18 14·9	18 55 S.	Sept.	29,	21 0	*m*
R Scuti	18 41·6	5 20 S.	Oct.	3,		*M*
β Lyræ	18 46·0	33 14 N.	,,	4,	0 30	*M*
R Cygni	19 33·8	49 57 N.	,,	4,		*M*
S Aquilæ	20 6·5	15 18 N.	,,	3,		*m*
R Delphini	20 9·6	8 45 N.	,,	1,		*M*
T Vulpeculæ	20 46·8	27 50 N.	Sept.	30,	23 0	*m*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.		
Near η Aurigæ	75°	41° N.	October 2.	Swift.
	225	52 N.	October 2.	Slow, bright.
,, δ Draconis	290	68 N.	Swift.	

GEOGRAPHICAL NOTES.

On the 12th inst. the administration of the Congo State received intelligence by way of Zanzibar that Mr. H. M. Stanley, on leaving the basin of the Albert Nyanza, endeavoured to make his way southwards by passing to the west of the Victoria Nyanza, but was unsuccessful. He then went northwards, and reached the eastern shore of the lake, Emin Pasha accompanying him. Mr. Stanley made a long stay on the borders of the lake, awaiting supplies from Msalala and Jabora, for which he had sent. He left Emin Pasha on the eastern shore of the lake several months ago, and proceeded in the direction of Mombassa. Mr. Stanley is expected to reach the eastern coast of Africa towards the end of October next.

According to information received at Lloyd's from Tromsö, dated September 9, the German travellers Kukenthal and Walter, belonging to the Bremen Arctic Expedition, who were shipwrecked last spring in the *Bertina*, have arrived safely at Tromsö.

M. Joseph Martin, the French explorer, known in connection with his late expedition to Eastern Siberia, recently left Pekin with a small escort for Tibet, intending to proceed along the Great Wall, subsequently passing through the towns of Liang-Chow and Sining and the province of Koko-Nor, where he expects to arrive next spring. The object of the expedition is of a purely scientific character.

Mr. Frederick Jeppe, of Pretoria, has recently issued, through Dulau and Co., an excellent map of the Transvaal and neighbouring territories on the scale of 15·78 miles to an inch. It includes not only the Transvaal, but the Orange Free State and all the countries between these and the coast, from Delagoa Bay down to Pondoland. It goes north to close on the Zambesi, including Matabeleland, Bechuanaland, Griqualand West, and the northern parts of Cape Colony. There are, moreover, a number of special inset maps. The physical features, mountains, rivers, &c., are laid down clearly and in detail. The gold-fields are coloured yellow, the topography is almost exhaustive, and the map is really a gazetteer of the extensive and important region which it embraces. Mr. Jeppe gives a list of the various authorities which he has used in the compilation of his map, and these are the best and latest available.

SOCIETIES AND ACADEMIES.

Paris.

Academy of Sciences, September 9.—M. Des Cloizeaux, President, in the chair.—On the fixation of atmospheric nitrogen, by M. Berthelot.—Observations on the formation of ammonia and volatile azotised compounds at the expense of vegetable earth and of plants, by the same. He traces the researches, initiated by him six years ago, establishing the fixation, by earth and plants, of free nitrogen of the air, with the aid of mineral matters and living organisms. Analysis of the liquid condensed within a bell jar inclosing earth, or earth with vegetation, proves the exhalation (of ammonia, &c.) above referred to; and like the ptomaïnes, &c., produced by animals in a closed space, the products are toxical to the organisms yielding them.—On the nitrification of ammonia, by M. Th. Schlœsing. Small quantities of gaseous nitrogen (negligible in agricultural practice), are liberated during the oxidation of ammonia in soil. The author shows that the nitrification of ammonia put into a soil in the form of sulphate, may be effected very quickly, when favoured by the nature of the soil, its humidity and its temperature. In slow combustion of the organic matter of soil, through the agency of the nitric ferment, much more oxygen is used in burning the carbon and hydrogen, than in nitrification of the nitrogen. But in a soil enriched with ammonia, the activity of the ferment is much increased, in conveying oxygen to the ammonia, and it seeks from organic matter only the carbon needed for its development and multiplication.—On the bacteriological study of the lesions of contagious peripneumonia of the ox, by M. S. Arloing. He distinguishes a bacillus and three kinds of micrococci.—On some observations made at the Observatory of Algiers, by M. Ch. Trépied. The separation of the nucleus of Brooks's comet, affirmed by the Mount Hamilton observers, could not be certainly made out. This Observatory, begun in the spring of 1885, on a height (350 metres) overlooking Algiers, has now all its instruments except a photographic equatorial. M. Trépied notes that the telescopic image of a star, during the sirocco, becomes a continuous luminous spot, the intensity diminishing outwards; an effect, doubtless, of dust.—Observations of Brooks's comet and its companion, made at the Observatory of Algiers with the 0·50 m. telescope, by MM. Rambaud and Sy.—The spectro-photography of the invisible parts of the solar spectrum, by M. Ch. V. Zenger. He describes as advantageous combinations, prisms of quartz and anethol; of quartz and calcareous spar; of the latter and sulphide of carbon; and of rock salt and anethol. One prism of rock salt, with two of anethol, gives nine times more dispersion, and the red part is six times more dispersed between A and D, than by a 60° prism of rock salt.—Researches on sulphites, by M. P. J. Hartog.—On a new monobromized camphor; on the constitution of monosubstituted derivatives of camphor, by M. P. Cazeneuve. The new compound is obtained similarly to the chlorine compound, got by the action of hypochlorous acid, and has similar properties.—On phenoldisulphonic acid, by M. S. Allain-Le Canu.—Influence, on bare soil, of gypsum and clay, on the conservation of nitrogen, the fixation of atmospheric nitrogen, and nitrification, by M. Péchard. The sulphate of lime retains the ammonia in the state of sulphate, and contributes indirectly to the production of nitric acid, by keeping the nitrogen in a form easily nitrifiable; also directly, (in a way not well understood) by its power of deoxidation and reoxidation. Gypsum and clay, both added to sandy soil, concur in fixing ammonia; the former keeps the fixing power of the latter active by removing its ammonia in the state of sulphate easily nitrifiable (clay alone is rather adverse to nitrification).—Manufacture of red glasses for windows (twelfth and thirteenth centuries), by MM. Ch. Er. Guignet, and L. Magne. A microscopic examination of these old glasses shows that various effects were obtained by making two glasses act on each other. In one case of interior twisted marbling, *e.g.*, a yellowish glass (charged with iron protoxide) reddened only at its contact with the enveloping mass of greenish-blue glass (copper-oxide). In another case (parallel marbling), each pellicle of yellow glass is reddened at its two faces. M. Henrivaux has adopted a similar method at St. Gobain.

September 16.—M. Des Cloizeaux, President, in the chair.—On an adynamic gyrostatic constitution for the ether, by Sir William Thomson. He describes a system of small spheres, connected by rods, with terminal cups moving on the spheres, and, at their middle part, two gyroscopes, with outer rings at right angles to each other.—On an application of the electric transmission of force, made at Bourganeuf, by M. Marcel Deprez. Further details are given of the system, which has worked well since May. The high tension generator, driven by a turbine, has two rings on one shaft, excited by two rectilinear inductors parallel to the axis, having the four poles quite free. The receiver is similar. The machines for light are of the Gramme type; and with a line resistance of 23 ohms, about 50 per cent. of the force imparted to the generator is recovered in light.—Determination of the microbe producing contagious peripneumonia of the ox, by M. S. Arloing. Of the four he describes, he finds the *Pneumobacillus liquefaciens* (as he calls it) the essential element in the virus.—Observations of Brooks's comet and its companion, at Algiers Observatory, by M. Rambaud.—On the occultations of Jupiter's satellites, by M. Ch. André. With three different telescopes at Lyons, the time of contact determined differed to the extent of 2½ minutes; immersion being noted earlier, and emersion later, with the smaller instrument; also the apparent complete visibility of the satellite, continued after contact (as others have observed), is referred to. This is thought to be due to a zone of diffracted light, spread by the object-glass round the geometrical image of the planet, covering the focal image of the satellite.—On the calculations of Maxwell, relative to movement of a rigid ring round Saturn, by M. O. Callandreau.—On the heat of vaporization of carbonic acid near the critical point, by M. E. Mathias. He uses the heat of dilution of sulphuric acid in the water of the calorimeter, as a compensating source of heat, and finds Clapeyron's formula satisfactorily verified. At the critical point the latent heat, L, is rigorously *nil*.—On the use of the new Edison phonograph as a universal acoumeter, by M. Lichtwitz. With it, one may form *phonograms*, to serve as acoumetric scales, with vowels, consonants, syllables, words and phrases, &c., according to their intensity and acoustic value (as determined by O. Wolf). The sound-source being nearly constant, could be used to compare the hearing of different patients, or the same patient at different times. A set of uniform phonograms could be got by placing phonographs at a fixed distance from a reproducing instrument. Thus aurists in all countries could compare results.—Catadioptric objectives applied to celestial photography, by M. Ch. V. Zenger. Two correction lenses of magnesium glass, of the same focal length, one concave and the other convex, are inserted, the focal length of the system being identical with that of the spherical mirror. The time of exposure is reduced to a third or a quarter, for stars of a given size.—Some supplementary thermal data, by M. J. Ossipoff. Thermal formation of salts of phenylene diamines, by M. Léo Vignon. Comparing the heat of neutralization of the three diamines by hydrochloric acid, he finds orthophenylene diamine to show less than the meta isomer; which, again, shows less than the para. The bisubstituted derivatives of benzine studied by Berthelot and Werner present a similar case.—On the alcoholic fermentation of honey and the preparation of hydromel, by M. G. Gastine. Solutions of honey generally give but poor alcoholic fermentation. The author verified an idea that this is because the ferments, in a medium so poor in mineral and azotized matters, miss the conditions necessary to their evolution.—Physiological action of the poison of the terrestrial salamander, by MM. Phisalix and Langlois. The characteristic symptom is convulsion; and the poison acts successively on the cortical, bulbar, and medullary cells. Temperature rises rapidly, and dyspnœa occurs, followed by asphyxia. Arterial tension is increased.—Cyclone of Jougne, on July 13, 1889, by M. Ch. Dufour. This appeared at 1.15 p.m., on a very hot, calm, cloudy day, in the canton of Doubs, and tore along eastwards 6 km., with a rattle like thunder, lasting two to three minutes. Of many trees uprooted, those at the outset lay mostly east to west; those further on, mostly west to east. The width of region devastated grew from 100 to 250 metres. The intensity seems to have varied in this space, and to have been greater on the right than on the left side (probably through the velocity of translation being added to that of gyration in the former case). Curiously, the weather changed at the time of the cyclone, from dry and warm to cold and wet.

Stockholm.

Royal Academy of Sciences, September 11.—A new arrangement of the species of the cod-fishes, by Prof. A. F. Smitt.—On types of weather-maps, and on the latest dispositions as to the circulation of the meteorological observations of the Meteorological State Institute to the public in general, by Prof. R. Rubenson.—On the genus Prisciturben, Kunth, by Prof. G. Lindström.—Analytic construction of the integrals of a linear homogeneous differential equation of a circular ring, which does not include any singular place, by Prof. G. Mittag-Leffler.—Analytic construction of the invariants of a linear homogeneous differential equation, by the same.—Contribution to the history of the mathematical studies in Sweden during the sixteenth century, by Dr. G. Eneström.—On the constitution of the cumenyl-propin-acid, by Prof. O. Widman.—On hydro-canel-carbon-acid and some of its derivatives, by the same.—A contribution to the question of the re-adjustment of the atoms within the propyl group, by the same.—Derivatives of the ortho-amid-benzyl-alcohol, by Prof. Widman and Dr. Söderbom.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Hints to Travellers, 6th Edition (Royal Geographical Society).—Travels in France by Arthur Young during the Years 1787, 1788, and 1789: M. Betham-Edwards (Bell).—Contributions to Canadian Palæontology, vol. i. Part 2: J. F. Whiteaves (Montreal).—The Fauna of British India, including Ceylon and Burma; Fishes, vol. ii.: F. Day (Taylor and Francis).—The Hand-book of Jamaica for 1889-90 (Stanford).—A Treatise on Analytical Mechanics; vol. ii., Dynamics of a Material System, 2nd edition: B. Price (Oxford, Clarendon Press).—Animal Biology, 2nd edition: C. Lloyd Morgan (Rivingtons).—Notes on the Pinks of Western Europe: F. N. Williams (West).—Simple Shorthand: W. Heather (Groombridge).—The Birds in my Garden: W. T. Greene (R.T.S.).—First Mathematical Course (Blackie).—An Elementary Text-book of Geology: W. J. Harrison (Blackie).—On the Motion of the Heart and Blood in Animals: W. Harvey; Willis's Translation, revised and edited by A. Bowie (Bell).—The Rotifera or Wheel-Animalcules; Supplement: C. T. Hudson and P. H. Gosse (Longmans).—The British Moss-Flora, Part 12: R. Braithwaite (published by the Author).—A Monograph of the Horny Sponges: R. von Lendenfeld (Trübner).—Records of the Geological Survey of New South Wales, vol. i. Part 2, 1889 (Sydney, Potter).

CONTENTS.

THURSDAY, OCTOBER 3, 1889.

PSYCHOLOGY OF PROTOZOA.

The Psychic Life of Micro-organisms: a Study in Comparative Psychology. By Alfred Binet. Translated from the French by Thomas McCormack. (Chicago: The *Open Court* Publishing Company, 1889.)

Psycho-physiologische Protisten-Studien: experimentelle Untersuchungen. Von Dr. Max Verworn. (Jena: Gustav Fischer, 1889.)

THE first of these two works on the psychology of Protozoa is disappointing. Its main object, as indicated in its title, is to investigate the claims which from time to time have been put forward on behalf of unicellular organisms to the possession of consciousness and a certain low order of mental life. Therefore, looking to the position which M. Binet has gained as a successful worker in other departments of psychological inquiry, we were prepared at his hands to meet with a judicious treatment of facts in the light shed by a specially instructed mind. But, far from this, what we do meet with is the special pleading of an advocate who seems to hold a brief on behalf of his little friends, and is determined to force them into a position of intellectual prominence, no matter at what cost of psychological absurdity. Indeed, were it not that the title-page declares the authorship of this work, no one could possibly have supposed that it had been written by a man who had ever opened an elementary text-book on mental science.

In justification of so severe a criticism one or two quotations may be supplied. With regard to suprise and fear he says:—"We may reply upon this point, that there is not a single infusory that cannot be frightened, and that does not manifest its fear by a rapid flight through the liquid of the preparation. If a drop of acetic acid be introduced beneath the cover-glass, in a preparation containing quantities of Infusoria, the latter will at once be seen to flee in all directions like a flock of frightened sheep." His test to prove memory is—"Every time an animal repeats the same action under influence of the same excitations, that fact proves that the animal is possessed of memory." His one criterion of instinct is—"Preadaptation to an end not present, but remote." After such examples, it would be needless to adduce more.[1] In no part of the book is any distinction drawn between activities as reflex or automatic, and conscious or intentional; therefore, if a Protozoon performs any action which is in the smallest degree adaptive, the fact is always taken as in itself sufficient evidence of intelligent volition. Thus, to go no further than the above quotations from his preface, it never seems to have occurred to M. Binet that "rapid flight" in the presence of a stimulating agent may be due to causes other than "fear"; that every excitable tissue (whether *in situ* or excised) which repeats the same action under influence of the same excitation is not forthwith accredited by an experimental physiologist with any psychological "memory"; or that the heart need not necessarily be supposed to beat by "instinct," because each diastole is a "preadaptation" to the next systole.

But not only do we everywhere encounter this astonishing disregard of the most elementary principles of psychology: we are equally surprised at what may be termed a void of general sagacity. For example, in M. Binet's own opinion the strongest evidence he has to adduce in favour of intelligence on the part of "micro-organisms" consists in the behaviour of spermatozoa and spermatozoids towards ova and ovules. Thus, for example, he does not hesitate to say, by way of a general conclusion on this matter, "In fine, the spermatic element, in directing itself toward the ovule to be fecundated, is animated by the same sexual instinct that directs the parent organism towards its female"! In particular, he quotes the interesting researches of Prof. Pfeffer, who found that spermatozoids are strongly attracted by certain solutions (malic acid, &c.), so that they will crowd into a pipette filled with these solutions, even though the latter be strong enough to cause their death. Now, to any ordinary common-sense it must appear that in these facts we have evidence pointing directly away from the hypothesis of intelligent adjustment, and therefore towards the simpler hypothesis of some kind of chemical—or physiological—affinity.

Upon the whole, then, as we have said, M. Binet's work is disappointing; and, we may now add, the disappointment arises not only on account of its astonishing weakness in psychology, but also from its want of full acquaintance with the literature of the subject, and an absence of any original investigations on the part of the author himself.

Of quite a different stamp is the work of Dr. Verworn. Charged throughout with the experimental work of a physiologist, and with the analytical powers of a well-instructed mind, these "Protisten-Studien" are of much value both from a scientific and a philosophical point of view. Like M. Binet, Dr. Verworn has set himself primarily to consider the question as to whether, or how far, the Protozoa ought to be accredited with mental faculties. Therefore a considerable part of his elaborate treatise is devoted to an exposition of those psychological principles, a clear definition of which is so essential to any adequate treatment of this question. The exposition is judicious, and leads to the general conclusion that we have no evidence at all of even the lowest degree of mental life on the part of any of the unicellular organisms. In this connection we may remark that, while M. Binet quotes from an earlier paper Dr. Verworn's observations on the "house-building" habits of *Difflugia urceolata* as one of the most unequivocal examples of Protozoon intelligence, Dr. Verworn himself here furnishes a crushing refutation of this view. For he finds, as a result of experiments with powdered glass, that the *Difflugia* will crawl about among the particles without collecting any, so long as it is left undisturbed; but when irritated by shaking, its pseudopodia retract, and, while doing so, exude sticky little drops, which cause any minute particles over which they happen to pass to adhere and be carried along with the retracting filament, until

[1] Perhaps it is fair to M. Binet to state that these examples are drawn from his preface, which is mainly concerned with an attempt to show that the present writer has not done justice to the mental endowments of the Protozoa. This criticism the present writer has fully answered in the *Open Court*, July 11, 1889.

eventually, upon the total retraction of pseudopod, they are deposited on the substance of the organism. Thus the "house" is built by purely mechanical means, without any "intelligence" or "volition" on the part of *Difflugia*. In the *Contemporary Review* for April 1873, the late Dr. Carpenter alluded to similar habits of a certain marine Protozoa, saying: "The deep-sea researches on which I have recently been engaged have not exercised my mind on any topic so much as on the following." He then describes what he regarded as a selective choice by the Protozoa of *finer* particles of sand by some species, and *coarser* particles by other species, for the purpose of building into the structures of their shells. No doubt, however, if the process were carefully observed, it would be found that this apparently selective choice is really due to the size or quality of the adhesive drops on the pseudopodia, which may very well differ slightly in these respects among the different species.

Much the larger portion of Dr. Verworn's work is, as its title conveys, occupied with an account of his experimental researches. These are thoroughly systematic and fairly exhaustive. First there are thirty pages describing the natural or spontaneous movements characteristic of well-known forms belonging to all the main divisions of the Protozoa. Next there follow a hundred pages dealing with the author's experiments in stimulation, arranged under the headings—luminous, thermal, mechanical, auditory, chemical, and electrical. Lastly, there are over fifty pages describing a number of experiments in various forms of section and artificial division of sundry unicellular organisms. The whole of this part of the research is exceedingly good, and must be studied by everyone who is engaged in practical work. From this point of view the two most interesting facts are, we think, the following. It is a general law of excitable tissues that the principal seat of excitation is the kathode on closing a galvanic circuit, and the anode on opening it. But Dr. Verworn finds that among the Protozoa the reverse of this otherwise general rule obtains. It appears that this curious observation was first made by Kühne as long ago as 1864; but Dr. Verworn has done good service in now calling attention to it, corroborating, and extending it to other unicellular organisms.

The second fact to which we allude is, that when a galvanic current is closed through a drop of water containing a number of Protozoa (*e.g. Paramecium*, *Coleps*, *Colpoda*, *Stentor*, *Halteria*), they will all begin to travel rapidly and directly to the negative pole, and, if the current be left closed for a few seconds, will all become congregated thereat. On now opening the current they will all begin to travel towards the positive pole, but then soon segregate. It was proved that this is not any merely physical phenomenon, but a truly vital one: the Protozoa of the genera named will invariably swim towards the kathode on closing, remain at the kathode so long as the current continues to pass, and swim towards the anode as soon as the current is opened. Even when the kathode is a copper wire, which causes the death of all the Protozoa that approach it, they will equally well congregate in its vicinity, there to perish; and by using a movable kathode of harmless material, the Protozoa may be led about like a flock of sheep following their shepherd. To this curious physiological property on the part of Protozoa, Dr. Verworn has assigned the name "Galvanotropism." But one would like to be informed as to the strength of the current employed, *e.g.* if it were sufficient to induce electrolysis. If the current used was a very weak one, would it not be interesting to try the effect of greatly strengthening it?

The experiments in section were all devoted to testing the value of the nucleus as a co-ordinating centre of movements, ciliary and otherwise. The results were uniformly opposed to the views of Rossbach, Engelmann, and others who have regarded the nucleus in this light—the un-nucleated portions of several Protozoa continuing to exhibit all the same spontaneous movements as the nucleated. It is to be regretted that the author did not more completely extend these researches to an investigation of the functions of the nucleus in respect of nutrition and regeneration, where so much still remains to be done. But we may hope that this is perhaps to follow.

GEORGE J. ROMANES.

OUR BOOK SHELF.

Treatise on Trigonometry. By W. E. Johnson, M.A. (London: Macmillan and Co, 1889.)

WE have here a work which should prove very serviceable to those who are commencing the subject with the hope of proceeding to more advanced mathematics, and also to those wishing to revise their study of trigonometry and to extend it beyond the limits of an ordinary elementary text-book.

The volume is divided into two parts, geometrical and analytical, the former dealing with geometrical applications, the latter with the purely theoretical and analytical side of the subject. The first part deals with the properties of points and circles connected with triangles and rectilinear figures, trigonometrical ratios and their fundamental relations; chapter ix. treats of the geometry of the triangle, including the nine-point circle, the cosine and ex-cosine circles; and in chapter x. we have formulæ for circles and rectilineal figures. In the algebraical part, logarithms, ratios of compound and multiple angles, developments of formulæ for the sums of angles, factorization and summation, are dealt with. In chapter xviii. the proof of the binomial theorem is a modification of Euler's, thereby making it depend directly on the index theorem. Chapter xxi. consists of the application to trigonometrical formulæ of imaginary and complex quantities, and chapter xxii. of a geometrical interpretation of imaginaries.

Short digressions have been made into geometry, algebra, and theory of equations in various parts of the work, thus bringing out more clearly the train of reasoning that is necessary to establish and expound the principles that lie at the foundation of mathematics, to which, in trigonometry, the student is first introduced.

At the end of each chapter is a copious supply of examples, and the book concludes with a set of miscellaneous examples and answers to the above.

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.*]

Taming the Puma.

As I believe that the puma, or Rocky Mountain lion, is usually considered one of the most intractable and untamable of animals, the following brief account of what I have just seen here, at the close of a brief tour in the Yellowstone National Park, may be of interest:—

Three years ago, Messrs. Wittich Bros., of this city, found some puma cubs in the valley of the Yellowstone River, twenty-five miles from this city. As cubs they showed those spots on the skin to which Mr. Muybridge called our attention at the Royal Society *soirée*, last May, as seen in his photographs of the adult animal, though not in that case visible to the eye. One of these cubs soon died, but the other is now three years old, and is perfectly under the control of Mr. W. F. Wittich, who devoted eighteen months to training her. I saw many proofs of this in his store this evening. The beast not having been fed for twenty-four hours, he trailed pieces of raw meat over her nose and mouth, which the puma never attempted to eat until the word was given, as to a dog. Occasional attempts were made, but a twist of the ear by Mr. Wittich was sufficient to control her. When meat was placed a few yards off, the puma fetched it by word of command, and permitted the meat to be taken from her mouth by Mr. Wittich, who fondled it as he would a cat. A very fine dog, a cross between a pure setter and a pure St. Bernard, five years old, named "Bruce," is on intimate, and even affectionate, terms with the puma, who allowed him to remove meat placed upon her jaws, and to eat it. On one occasion, the puma (who is often allowed to range the house), the dog, and Mr. Wittich, slept together in the same bed, and Mr. Wittich was aroused by the puma attacking some one who roused him in the early morning. When the puma is tied up, the dog always goes to sleep alongside her, and kisses her, the puma responding with a short sharp bark of greeting. The puma follows Mr. Wittich through the streets of this Western city, but has torn to pieces several strange dogs, when unaccompanied by her friend "Bruce." I inclose you a photograph of the dog in the act of removing meat from in front of the puma's jaws; her paws are done justice to, but not the length of her tail. Prior to the exhibition, Mr. Wittich requested the spectators (about ten in number) to remain perfectly still, as the beast (which was loose) noticed, and was angered by, any movement on their part.

Mr. Wittich believes that this is the only puma known to be in captivity, and comparatively tame. In training her he has chiefly used the whip, which she only feels on the nose, ear, and under the tail; he assures me he has made his own teeth meet through her skin in several other parts of her body without her showing any signs of sensation. Her memory is short, and three weeks' intermission of the performance necessitates much extra training and trouble.

I may perhaps add that Mr. W. R. Goodall, an English gentleman who has been living nearly three years ten miles from here on a ranche, assures me that perfect reliance can be placed on Mr. Wittich's statements. What my fellow-travellers and I saw ourselves was sufficiently marvellous, and I am not ashamed to add that we felt somewhat relieved when the animal, which had circulated freely among us, was chained up again! WM. LANT CARPENTER.

Livingston, Montana, U.S.A., August 30.

On some Effects of Lightning.

THE terrific storm which passed over Essex on the night of Monday, the 2nd inst., should give many interesting examples of the effects of lightning. I was at Upminster, 2½ miles from Romford, on the morning following, and had the opportunity of examining a windmill for corn-grinding which had been struck. Perhaps the details may prove of some interest.

The owner, Mr. J. Abraham, and a friend witnessed the flash, which occurred at about 1 a.m., from a window not far from the mill. They describe it as a mass or network of flame, which threw off thousands of sparks like fireworks. After the flash a light appeared on the sail for a few seconds, and they feared the mill would catch fire, but it went out, extinguished, as they suppose, by the heavy rain (I recorded 4·00 inches in seven hours in a field a mile away). I consider it remarkable that the mill was not fired. The splintered wood and cracked boards do not, however, at any attainable point show signs of charring.

The mill is octagonal, and of wood, standing on about 8 feet of brickwork. The joints of the weather boards at the angles are protected by thin sheet lead in strips about 6 × 3 inches, bent over the edge of each board to the next and nailed. At the base of the wooden part is a platform 10 feet wide, and the angle which this makes with the body is also protected with sheet lead. The strips up the angles are connected with this ring round the base, and from the ring again many strips are nailed radially to the edge of the platform. A chain was hanging from top to bottom of the mill, nearly touching the weather boards at the top, and hanging within 2 inches of the boarded ground floor at a distance of about 4 feet from the circumference in the south radius. The upper cap of the mill is revolvable. The sails faced south-east, and were set diagonally.

All the effects of the flash seem to me to indicate that it passed from earth to cloud. One branch of it passed through the iron chain, fusing the links at the points of contact, sufficiently to make them hold together when first disturbed. The flash burst through the weather boarding at the top, breaking the boards away outwards, and then reached one of the iron levers used for opening and closing the shutters of the sails. I was surprised to find no traces of the flash on the boards at the ground. The bottom link of the chain was fused, and there all trace ceased.

A second branch joined the first at the iron lever, coming in the direction described in what follows. Against the north-north-west angle of the platform runs a leaden valley gutter between two outbuildings. The flash seems to have sprung, from some old iron, lying on the ground, to this gutter, and run along it. A small portion went along under the edge of the platform to the west-north-west angle, and then along one of the radial strips. The larger portion entered at once at the north-north-west angle along a radial strip, tearing up the end of it and bending it over on to the platform. On reaching the ring of lead at the base it went round it in both directions, tearing up the lead at every junction, and bending it in the direction of the current. It then ascended by the south-south-east and east-south-east angles only, tearing up each lead strip and curling the end over upwards.

The portion ascending by the south-south-east angle joined that from the inside chain at the place where the boards were burst off. That ascending by the east-south-east angle made a path of its own to the sail lever by perforating a board of the weathering apron which depends from the revolving top of the mill. This perforation, seen from the nearest point I could attain, was evidently from within outwards. The board is cracked from the free edge to the point of perforation, but not badly nor further.

On reaching the ironwork of the sails the whole charge passed along the lever of the north-east sail, and on reaching the end of the metal entered the wood. The framework of this was shattered, the shutters smashed and thrown about, bolts broken, and the main shaft splintered. Large pieces were thrown 50 yards and more into an adjoining field.

The charge appears to have left the sail before reaching the extreme end, but as the miller was awaiting the arrival of the Insurance Company's inspector he did not wish to have the sail lowered, and I could not inspect it.

In a few places the lead was partly melted. At some holes where nails were put in, little circles half an inch in diameter were melted cleanly out, and in one place I found the head of a nail partly fused.

I was surprised to find so little damage done to the mill, and think it is a very good illustration of Mr. Tomlinson's remarks in NATURE of August 15 (p. 366), where he suggests that a building to be well protected should have a network of conducting material attached to it. ARTHUR E. BROWN.

31 Vanbrugh Park, Blackheath, September 10.

WITH regard to the two lightning-struck trees near St. Albans, the twisting mentioned by Mr. Pickering is probably not in any way due to the fact that the stroke was dealt by lightning. It is easily accounted for on mechanical principles, even assuming that the toughness of the timber was exactly equal in every part. If the centre of gravity of the dislocated top of the tree lay outside of a certain plane passing through the point of explosion (the position of this plane depending on the tenacity of the stem at that level), such twisting would be inevitable; much as in an earthquake dislocated columns must always be twisted unless the friction of the dislocated surface is equivalent on each side of a certain line running parallel to the direction of motion.

If Mr. Pickering has an opportunity, he might perhaps be able to ascertain whether or no the "core" of each tree is "not exactly in the middle of each stem, but rather to the side remote from that to which the top has fallen" (see my former letter). If this is the case, it would be strong proof that the explosion actually took place in the core. I shall probably have no opportunity of visiting the spot again for many months.

My recollection is that there are no trees within several feet of the line joining the two damaged ones, which stood in what now looks like an opening in the wood. Mr. Pickering can perhaps check this also. A. F. GRIFFITH.

15 Buckingham Place, Brighton.

IN several letters lately published in NATURE, an explosion in or by a tree trunk is mentioned. Such an explosion occurred here during the great storm of July 12 last. The lightning struck an old crab-tree, at the base of the trunk, and exactly at the ground-line. The crab was growing on the top of a grassy bank. The lightning tore the bank open from top to bottom, tore open and splintered the roots of the crab, and threw pieces of roots and turf, all in one direction, for 21 feet; the turf was in large pieces, of about a foot cube.

A tiled barn near here was, at the same time, struck in a peculiar manner. The lightning struck the upper tiles near a gable; one tile was torn out and hurled away, and several other tiles were neatly perforated with round holes, each about ¼ inch in diameter; the tiles were red, and the holes were burnt grey all round. The wooden pegs belonging to the perforated tiles were blackened by the heat. W. G. S.

Dunstable.

On the Remarkable Form of Hailstones.

WITH reference to the description given in NATURE (vol. xl. pp. 151 and 272) of the hailstorm at Liverpool, it will probably be interesting to bring under notice an early account of the remarkable forms often possessed by hailstones; it is to be found in the *Edinburgh Philosophical Journal* for 1824, vol. xi. p. 326. The writer of the said article states that "in the second part of the eleventh volume of the 'Nova Acta Physico-Medica Academiæ Cæsareæ Leopoldinæ Carolinæ Naturæ Curiosorum,' Dr. Nögerath informs us, that, on May 7, 1822, a tremendous hail-shower fell in and around Bonn. . . . The general size of the hailstones was about one inch and a half in diameter, with a weight of nearly 300 grains. When whole, which was not generally the case, the general outline was elliptical or compressed globular, and the form *cerebral*, or resembling the brain of a warm-blooded animal. . . . More frequently the form was lenticular, and appeared polished on the two ends, as if by friction. The masses had a concentric lamellar structure; in the centre was a white, nearly opaque, nucleus, of a round or elliptical form, around which were arranged concentric layers, which increased in translucency from the innermost to the outermost. They at the same time exhibited a beautiful stellular fibrous arrangement, caused by rows of air-bubbles disposed in radii. . . . Captain Delcross, in the thirteenth volume of the 'Bibliothèque Universelle,' describes hailstones having the concentric lamellar structure and stellular fibrous arrangement. . . .The surface was provided with pyramidal forms. . . . When the edges and the angles of the pyramids are melted down, the *cerebral* form is produced; when the masses of hail, having the structures described, burst asunder, the fragments have a pyramidal form, and then forms what has been described under the name of *pyramidal hail*." The writer then proceeds to describe hailstones which fell on June 27, 1823, at Aberdeen. "They (the hailstones) were included, almost universally, each by five sides or surfaces, four plane, constituting the sides of an irregular pyramid, and one spherical in place of a base. . . . The spherical surface appeared, to the depth of one-twentieth or one-thirtieth of an inch, to be solid as it was transparent. The rest of the hailstone was opaque, consisting of crystals or minute columnar forms, perpendicular to the spherical surface." Eight figures, illustrative of the different kinds of hailstones, are given (Plate ix.).

Miss Holt refers to the metallic taste and the flavour of ozone possessed by those which fell at Liverpool. The presence of NH_3 in hailstones was long ago established by Mène (*Comptes rendus*, May 19, 1851). J. SHEARSON HYLAND.

14 Hume Street, Dublin.

Erinus hispanicus (?) on the Roman Wall.

THE accompanying note on this alien Scrophulariaceous plant will, I think, be of interest to many of your readers, more especially to those who, as members of the British Association, took part in the excursion on Thursday last from Newcastle to the Roman Wall.

The plant occurs on some Roman remains at Chesters, Chollerford, Northumberland, the residence of Mr. John Clayton. In the recent editions of Dr. Bruce's "Hand-book to the Roman Wall," it is named *Erinus hispanicus*, but it appears to have been previously known as *E. alpinus*. In endeavouring to determine its authoritative name, I have ascertained that the plant was called *E. hispanicus* by Persoon ("Synopsis"), who regarded it as a doubtful species, whereas all other authors regard it as a variety of *E. alpinus*. There is a specimen, apparently of this plant, in the Oxford Herbarium, collected by Endress ("Plantæ Pyrenaicæ exsiccatæ, Annis 1829–30 lectæ") which he calls *E. alpinus*, var. *lanuginosus*; Grenier and Godron ("Flore Française") call it *E. alpinus*, var. *hirsutus*; Lange calls it *E. alpinus*, var. *villosus*; and Willkomm and Lange, in their "Flora Hispanica," follow Grenier and Godron, giving the other names as synonyms. It will doubtless be best to accept Willkomm and Lange's conclusion, and adopt the name *E. alpinus*, var. *hirsutus*, Grenier et Godron.

I may add that *E. alpinus*, L., is mentioned, in Babington's "Manual of British Botany," as occurring near Tanfield, in Yorkshire, a locality which is also given in the last edition of Hayward's "Botanist's Pocket-Book." However, in Arnold Lees's "Flora of West Yorkshire" (1888), it is stated that this plant has disappeared from Tanfield. Consequently Chesters is now the only English locality for *Erinus*, and the only form is the var. *hirsutus*. SYDNEY H. VINES.

Oxford, September 23.

Noctilucous Clouds.

THE recent communications in NATURE in relation to apparently self-luminous cloud-like bands in the skies after nightfall, call to mind the analogous phenomena of noctilucous clouds involving the whole visible firmament.

We are indebted to the indefatigable industry and zeal of the illustrious Arago for the collection of the scattered facts relating to the phenomena of self-luminous clouds of divers kinds.[1] According to the records collected by him, noctilucous bands and zones of clouds are sometimes associated with the electrical manifestations accompanying distant thunderstorms. To this class belong the luminous phenomena noticed by Rozier on August 15, 1781, and by Nicholson on July 30, 1797. In other cases, the association of the phenomena with electrical disturbances, is by no means obvious. To this class belong the luminous clouds observed by Beccaria over his observatory at Turin; likewise the luminous appearances witnessed by Deluc near London, and also those observed by Major Sabine over the Isle of Skye in Scotland. In all these cases, the noctilucous condition of the clouds was localized and confined to bands or zones in limited portions of the sky. But under certain conditions this apparently self-luminous property of the nocturnal clouds involves the entire visible hemisphere. It is to this latter aspect of the noctilucous phenomena that I desire to call attention.

Omitting the consideration of the exceptionally rare and anomalous phenomena of so-called phosphorescent "dry-fogs," as those of 1783 and 1831, in which the luminosity was so pronounced as to enable one to read ordinary print at midnight, we come at once to the generally recognized phenomenon of that faint diffused cloud-luminosity which enables the "country doctor," with comparative security, to perform his lonely midnight drives on cloudy moonless nights. Frequently the glow is so faint that it is only possible to observe it at a distance from cities and large towns, in places where the air is free from smoke, and where the darkness of the sky is not affected by the general illumination due to gas and electric lights.

The conditions under which the phenomena most conspicuously manifested themselves to my observations were during the incipient stages of the autumnal north-east storms occurring

[1] *Annuaire du Bureau des Longitudes pour l'An* 1832, pp. 246–50; *ibid.*, 1838, pp. 279–85. "Œuvres Complètes de Arago," vol. iv. pp. 70–77. Arago's "Meteorological Essays," translated by Sabine, pp. 48–53 (London, 1855).

near the sea-coast of Georgia (U.S.A.). In these three-days cyclonic storms, before the rain begins and usually before the lowest strata of air are sensibly disturbed by the upper currents, the low-lying dense masses of clouds coming from the north-east scud across the skies with great rapidity. Under these circumstances, during moonless nights, the general illumination is sufficient to plainly indicate the road to the traveller, even when it is bordered by tall overhanging trees. Under ordinary circumstances, an equivalent degree of cloudiness would have compelled the traveller to abandon all attempts at guiding the horse, and to rely entirely upon the superior acuteness of the nocturnal vision of his equine companion. In such storms, the cloudiness involves the entire firmament, and there are no electrical manifestations. To the traveller, the general illumination apparently surpasses that of a starlight cloudless night.

Now the question is, What is the origin and source of this general nocturnal illumination on cloudy moonless nights? No degree of cloudiness seems to completely obliterate the faint illumination. For, as Arago intimates, even when the heavens are overcast, during moonless nights, and the stars are hidden by an unbroken mass of the most dense clouds, there is a sufficiency of diffused light in the open country to prevent the difficulty and inconvenience which would attend any attempt to walk in the Cimmerian darkness of a cavern.

It is a popular opinion that the clouds act like ground-glass lamp-shades in diffusing the aggregate starlight, so as to produce a faint illumination from all parts of the sky, and thus obliterating shadows on the surface of the earth due to the greater amount of light radiated from the more luminous regions of the celestial vault. But Arago justly maintains that when we consider the immense effect of clouds in weakening the dazzling light of the sun on particular days in winter, it is scarcely possible to admit that the faint diffused light, which, on a cloudy night, guides the steps of the traveller, comes from the stars. In other terms, in view of the loss from reflection and absorption, the amount of starlight penetrating the cloud-canopy seems to be quite inadequate to account for the degree of general illumination observed at the surface of the earth. If we exclude the stellar origin, there remains no other explanation of the nocturnal light of a clouded sky, except the admission that the clouds themselves have a luminosity of their own. This is the view taken by Arago.

But since, for all degrees of obscuration, more or less of the starlight incident upon the canopy of clouds must penetrate it, and be diffused at the surface of the earth, this source of luminosity must be looked upon as a *vera causa*. Its adequacy to explain the observed illumination in any given case will depend upon the density of the overcasting cloudy masses and upon the sensitiveness of the human organ of vision. Hence it seems to be more rational to conclude that some portion of the nocturnal luminosity of clouds may be due to the faint diffused starlight; but that, when the amount of illumination from comparatively dense noctilucous clouds surpasses that of clear moonless nights, we are warranted in assigning them self-luminous properties. This seems to have been the condition of the low, dense, and rapidly-drifting clouds observed by me during the incipient stages of north-east storms on the Atlantic coast. Moreover, the fact that an equal degree of cloudiness is not always attended with an equal amount of illumination points to the same conclusion. In other words, it seems to be reasonable that the degree of luminosity sometimes manifested in the deep winter nights, when the whole heavens are overcast with dense clouds, is vastly too great to be due to diffused stellar light, and is more probably ascribable to the greater or less self-luminous properties of the clouds themselves.

In the case of isolated clouds, augmented nocturnal brightness may be due to well-known local causes, independent of self-luminosity. For example, the source of the brightness of the clouds observed by Prof. Piazzi Smyth in 1882 and 1883, was traced by him to the reflection of the gas-lights of the city of Edinburgh, from water-drops in the clouds (NATURE, vol. xxviii. p. 239). In like manner, the bright nocturnal clouds observed by Mr. T. W. Backhouse and others in 1886 (NATURE, vol. xxxiv. pp. 239, 312, 386) were probably due to bands of lofty clouds illuminated by the lingering sunlight.

But even in cases in which the noctilucous condition of the clouds is general, it is more than possible that the starlight illumination may be reinforced by the prolonged twilights due to the reflection of sunlight from attenuated solid particles suspended in the supra-cirrus strata of the atmosphere, such as were manifested after the Krakatão eruption in the autumn of 1883. Moreover, in certain cases the stellar illumination may be strongly augmented by cloud-obscured auroral lights. These several possible sources of extra-stellar illumination of the sky during cloudy nights seem almost to preclude the necessity of the assumption of the existence of the condition of self-luminosity of clouds under any circumstances.

But, admitting the occasional self-luminous condition of clouds, the question is, What are the physical causes of their luminosity? It is customary to refer such obscure luminous phenomena to phosphorescence or to electricity. But it must be confessed that, in the absence of definite knowledge of the physical causes of the phosphorescence of clouds, on the one hand, or of distinct electrical manifestations in such clouds, on the other, such explanations, so far from enlightening us, would seem to be more akin to illustrating the obvious by the obscure.

Seafaring men must have had numerous opportunities of observing nocti'ucous clouds in various latitudes under every degree of obscuration; but I do not, at present, recollect any reference to such observations on the ocean. In "The Voyage of H.M.S. *Challenger*," in the "Memorandum of Meteorological Observations," under head "Weather," there is a record of the "visibility of distant objects"; but I have been unable to find any night-observations of visibility ("Narrative," vol. ii. p. 300 *et seq.*).

Berkeley, California, August 30. JOHN LE CONTE.

ON BOSCOVICH'S THEORY.[1]

WITHOUT accepting Boscovich's fundamental doctrine that the ultimate atoms of matter are points endowed each with inertia and with mutual attractions or repulsions dependent on mutual distances, and that all the properties of matter are due to equilibrium of these forces, and to motions, or changes of motion produced by them when they are not balanced; we can learn something towards an understanding of the real molecular structure of matter, and of some of its thermodynamic properties, by consideration of the statical and kinetic problems which it suggests. Hooke's exhibition of the forms of crystals by piles of globes, Naviers's and Poisson's theory of the elasticity of solids, Maxwell's and Clausius's work in the kinetic theory of gases, and Tait's more recent work on the same subject—all developments of Boscovich's theory pure and simple—amply justify this statement.

Boscovich made it an essential in his theory that at the smallest distances there is repulsion, and at greater distances attraction; ending with infinite repulsion at infinitely small distance, and with attraction according to Newtonian law for all distances for which this law has been proved. He suggested numerous transitions from attraction to repulsion, which he illustrated graphically by a curve—the celebrated Boscovich curve—to explain cohesion, mutual pressure between bodies in contact, chemical affinity, and all possible properties of matter—except heat, which he regarded as a sulphureous essence or virtue. It seems now wonderful that, after so clearly stating his fundamental postulate which included inertia, he did not see inter-molecular motion as a necessary consequence of it, and so discover the kinetic theory of heat for solids, liquids, and gases; and that he only *used* his inertia of the atoms to explain the known phenomena of the inertia of palpable masses, or assemblages of very large numbers of atoms.

It is also wonderful how much towards explaining the crystallography and elasticity of solids, and the thermo-elastic properties of solids, liquids, and gases, we find without assuming more than one transition from attraction to repulsion. Suppose, for instance, the mutual force between two atoms to be repulsive when the distance between them is $< Z$; zero when it is $= Z$; and attractive when it is $> Z$: and consider the equilibrium of groups of atoms under these conditions.

[1] Abstract by the Author of a communication to Section A of the British Association, on Friday, September 13, at Newcastle.

A group of two would be in equilibrium at distance Z; and only at this distance. This equilibrium is stable.

A group of three would be in stable equilibrium at the corners of an equilateral triangle, of sides Z; and only in this configuration. There is no other configuration of equilibrium except with the three in one line. There is one, and there may be more than one, configuration of unstable equilibrium, of the three atoms in one line.

The only configuration of stable equilibrium of four atoms is at the corners of an equilateral tetrahedron of edges Z. There is one, and there may be more than one, configuration of unstable equilibrium of each of the following descriptions:—

(1) Three atoms at the corners of an equilateral triangle, and one at its centre.

(2) The four atoms at the corners of a square.

(3) The four atoms in one line.

There is no other configuration of equilibrium of four atoms, subject to the conditions stated above as to mutual force.

In the verbal communication to Section A, inportant questions as to the equilibrium of groups of five, six, or greater finite numbers, of atoms were suggested. They are considered in a communication by the author to the Royal Society of Edinburgh, of July 15, to be published in the Proceedings before the end of the year. The Boscovichian foundation for the elasticity of solids with no inter-molecular vibrations was slightly sketched, in the communication to Section A, as follows.

Every infinite homogeneous assemblage[1] of Boscovich atoms is in equilibrium. So, therefore, is every finite homogeneous assemblage, provided that extraneous forces be applied to all within influential distance of the frontier, equal to the forces which a homogeneous continuation of the assemblage through influential distance beyond the frontier, would exert on them. The investigation of these extraneous forces for any given homogeneous assemblage of single atoms—or of groups of atoms as explained below—constitutes the Boscovich equilibrium-theory of elastic solids.

To investigate the equilibrium of a homogeneous assemblage of two or more atoms, imagine, in a homogeneous assemblage of groups of i atoms, all the atoms except one held fixed. This one experiences zero resultant force from all the points corresponding to it in the whole assemblage, since it and they constitute a homogeneous assemblage of single points. Hence it experiences zero resultant force also from all the other $i - 1$ assemblages of single points. This condition, fulfilled for each one of the atoms of the compound molecule, clearly suffices for the equilibrium of the assemblage, whether the constituent atoms of the compound molecule are similar or dissimilar.

When all the atoms are similar—that is to say, when the mutual force is the same for the same distance between every pair—it might be supposed that a homogeneous assemblage, to be in equilibrium, must be of single points; but this is not true, as we see synthetically, without reference to the question of stability, by the following examples, of homogeneous assemblages of symmetrical groups of points, with the condition of equilibrium for each when the mutual forces act.

Preliminary.—Consider an equilateral[2] homogeneous assemblage of single points, O, O′, &c. Bisect every line between nearest neighbours by a plane perpendicular to it. These planes divide space into rhombic dodekahedrons. Let A_1OA_5, A_2OA_6, A_3OA_7, A_4OA_8, be the diagonals through the eight trihedral angles of the dodekahedron inclosing O, and let $2a$ be the length of each. Place atoms Q_1, Q_5, Q_2, Q_6, Q_3, Q_7, Q_4, Q_8, on these lines, at equal distances, r, from O; and do likewise for every other point, O′, O″, &c., of the infinite homogeneous assemblage. We thus have, around each point A, four atoms, Q, Q′, Q″, Q‴, contributed by the four dodekahedrons of which trihedral angles are contiguous in A, and fill the space around A. The distance of each of these atoms from A is $a - r$.

Suppose, now, r to be very small. Mutual repulsions of the atoms of the groups of eight around the points O will preponderate. But suppose $a - r$ to be very small: mutual repulsions of the atoms of the groups of four around the points A will preponderate. Hence for some value of r between O and a, there will be equilibrium. There may, according to the law of force, be more than one value of r between O and a giving equilibrium; but whatever be the law of force, there is one value of r giving *stable* equilibrium, supposing the atoms to be constrained to the lines OA, and the distances r to be constrainedly equal. It is clear from the symmetries around O and around A, that neither of these constraints is necessary for mere equilibrium; but without them the equilibrium might be unstable. Thus we have found a homogeneous equilateral distribution of 8-atom groups, in equilibrium. Similarly, by placing atoms on the three diagonals, B_1OB_4, B_2OB_5. B_3OB_6, through the six tetrahedral angles of the dodekahedron around O, we find a homogeneous equilateral distribution of 6-atom groups, in equilibrium.

Place, now, an atom at each point O. The equilibrium will be disturbed in each case, but there will be equilibrium with a different value of r (still between o and a). Thus we have 9-atom groups and 7-atom groups.

Thus, in all, we have found homogeneous distributions of 6-atom, of 7-atom, of 8-atom, and of 9-atom groups, each in equilibrium. Without stopping to look for more complex groups, or for 5-atom or 4-atom groups, we find a homogeneous distribution of 3-atom groups in equilibrium by placing an atom at every point O, and at each of the eight points A_1, A_5, A_2, A_6, A_3, A_7, A_4, A_8. This we see by observing that each of these eight A's is common to four tetrahedrons of A's, and is in the centre of a tetrahedron of O's; because it is a common trihedral corner point of four contiguous dodekahedrons.

Lastly, choosing A_2, A_3, A_4, so that the angles A_1OA_2, A_1OA_3, A_1OA_4 are each obtuse,[1] we make a homogeneous assemblage of 2-atom groups in equilibrium by placing atoms at O, A_1, A_2, A_3, A_4. There are four obvious ways of seeing this as an assemblage of di-atomic groups, one of which is as follows:—Choose A_1 and O as one pair. Through A_2, A_3, A_4 draw lines same-wards parallel to A_1O, and each equal to A_1O. Their ends lie at the centres of neighbouring dodekahedrons, which pair with A_2, A_3, A_4 respectively.

For the Boscovich theory of the elasticity of solids, the consideration of this homogeneous assemblage of double atoms is very important. Remark that every O is at the centre of an equilateral tetrahedron of four A's; and every A is at the centre of an equal and similar, and same-ways oriented, tetrahedron of O's. The corners of each of these tetrahedrons are respectively A and three of its twelve nearest A neighbours; and O and three of its twelve nearest O neighbours. By aid of an illustrative model showing four of the one set of tetrahedrons with their corner atoms painted blue, and one tetrahedron of atoms in their centres, painted red, the mathematical theory which the author had communicated to the Royal Society of Edinburgh, was illustrated to Section A.

In this theory it is shown that in an elastic solid constituted by a single homogeneous assemblage of Boscovich atoms, there are in general two different rigidities, n, n_1, and

[1] "*Homogeneous assemblage of points*, or *of groups of points*, or *of bodies*, or *of systems of bodies*," is an expression which needs no definition, because it speaks for itself unambiguously. The geometrical subject of homogeneous assemblages is treated, with perfect simplicity and generality by Bravais, in the *Journal de l'École Polytechnique*, cahier xix. pp. 1–128 (Paris, 1850).

[2] This means such an assemblage as that of the centres of equal globes piled homogeneously, as in the ordinary triangular-based, or square-based, or oblong-rectangle-based, pyramids of round shot or of billiard balls.

[1] This also makes A_2OA_3, A_2OA_4, and A_3OA_4 each obtuse. Each of these six obtuse angles is equal to $180° - \cos^{-1}(1/3)$.

one bulk-modulus, k; between which there is essentially the relation

$$3k = 3n + 2n_1,$$

whatever be the law of force. The law of force may be so adjusted as to make $n_1 = n$; and in this case we have $3k = 5n$, which is Poisson's relation. But no such relation is obligatory when the elastic solid consists of a homogeneous assemblage of double, or triple, or multiple Boscovich atoms. On the contrary, any arbitrarily chosen values may be given to the bulk-modulus and to the rigidity, by proper adjustment of the law of force, even though we take nothing more complex than the homogeneous assemblage of double Boscovich atoms above described.

The most interesting and important part of the subject, the kinetic, was, for want of time, but slightly touched in the communication to Section A. The author hopes to enter on it more fully in a future communication to the Royal Society of Edinburgh. WILLIAM THOMSON.

NOTES.

THE model of a memorial to Prjevalsky, which is to be erected on the shore of Lake Issyk-kul, is being exhibited at St. Petersburg. It represents a rock, upon which an eagle is descending, having a map of Asia in its talons, and an olive branch in its beak. The monument will have the inscription: "To the first explorer of Nature in Central Asia."

THE Durban Correspondent of the *Times* telegraphs that the Cape Government has decided to adopt Prof. Seeley's proposal for a geological survey under his charge. He believes that other eruptive diamond-bearing tracts like Kimberley exist elsewhere.

IT is understood that a sum of £2000 has been presented to the University of St. Andrews for the purpose of erecting buildings and equipping a chemical laboratory in connection with the Chemical Chair in the United College of St. Andrews.

THE late Alderman George, of Leeds, has bequeathed £10,000 to the Yorkshire College.

THE Harveian Oration will be delivered at the Royal College of Physicians by Dr. James E. Pollock, at 4 o'clock precisely, on Friday, October 18.

THE Queen has been pleased, on the recommendation of the Secretary for Scotland, to appoint Mr. R. Fitzroy Bell, advocate, to be Secretary to the Scottish University Commissioners, constituted under the Universities (Scotland) Act of last session.

ON Monday the International Congress of the Ethnographic Sciences was opened in Paris, at the Trocadéro, under the presidency of M. Jules Oppert, Member of the Institute and Professor at the College of France. In opening the proceedings M. Oppert defined the province of ethnography, and enumerated six sections into which the Committee of the Congress had divided the ethnographic sciences. These were: (1) general ethnology; (2) ethics and sociology; (3) ethnographic pyschology; (4) comparative religion, with a sub-section devoted to Buddhism; (5) philology; and (6) archæology and the fine arts.

THE Congress on Hydrology and Climatology meets in Paris to-day. After the meeting there will be an excursion to the Vosges.

AT the Colonial Exhibition in Paris, visitors may now obtain pamphlets, issued by the French Government, concerning the different colonies, their resources, and the advantages they offer to immigrants. Those relating to the Victoria and the New Zealand exhibits are very good.

AT St. Petersburg, on September 7, several Pulkova astronomers and geodesists took advantage of the ascent of a balloon, belonging to the Technical Society, to test the accuracy of barometrical measurements. The aëronauts, who reached a height of 1800 metres, took with them, besides chronometers and various meteorological instruments, a barometer, a barograph, and an aneroid; and they obtained, in addition to the curve of the barograph, the various heights at which the balloon stood during its ascent and descent for twenty-eight different moments. The heights obtained from these measurements will be compared with those found by geodetical angular measurements, which were made at five different places as far distant from one another as Cronstadt, the St. Petersburg University, Kolpino, and Pargolovo; that is, at distances of more than thirty miles between the extreme stations. The geodetical measurements thus secured are now being calculated.

THE Brussels Correspondent of the *Times* points out that the number of foreign students at the German Technical High Schools is steadily increasing, especially at Berlin, where, last year, there were thirteen English students preparing for the professions of mechanical and mining engineers, architects, and chemists.

WE regret to announce the death, at Manila, on July 28 last, of Senor Don Sebastian Vidal, Inspector-General of the Philippine Island Forests and Director of the Manila Botanic Garden. He held the post for a considerable period, and was the author of numerous important works on Philippine botany. He paid two visits to this country in his official capacity; a first of two months' duration, in the autumn of 1877, and a second of four months', in 1883–84. Both periods were spent at Kew in working up the Philippine flora; and he deposited in the Herbarium a set of no less than 4062 specimens for future reference. His published works are:—"Catalogo metódico de la Plantas Leñosas observadas en la Provincio de Manila," 1880; "Rĕsena de la Flora del Archipiélago Filipino," 1883; "Sinopsis de Familias y Generos de Plantas Leñosas de Filipinas," 1883, with an atlas of 100 folio lithographed plates; "Phanerogamæ Cumingianæ Philippinarum," 1885; and "Revision de Plantas Vasculares Filipinas," 1886. The two latter were the result of his last visit to Kew, and he was assisted in their preparation by Mr. R. A. Rolfe of that establishment. Senor Vidal was the first to investigate the Philippine flora since the time of Blanco (when geographical botany as a science was practically non-existent), and we owe to him, not merely a widely extended knowledge of its constitution, but also the establishment of the fact that the Philippine flora, though substantially Malayan in character, yet presents a number of very important peculiarities. We cannot but announce the death of so energetic and promising a worker with profound regret, and hope that his successor will carry on the work with the same amount of success.

AN Indian native paper announces that the Newab of Junagadh has communicated with the Meteorological Department of the Government of India offering to start an observatory at Verawal, and to make suitable arrangements for the exhibition of storm signals for apprising the shipping of the port of the advent of storms in the Arabian Sea. The Dewan of His Highness has offered a building for housing the meteorological instruments, and proposes to erect a shed for the reception of the thermometers on a site near the seashore of Verawal, and to assist generally the Meteorological Department to start an observatory.

MR. HOWARD CUNNINGHAM, the Honorary Curator of the Wiltshire Museum, writes complaining that the monoliths of Stonehenge are being defaced by the names and initials of visitors, and that the inclosure has become "like a pigsty," owing to the litter of broken bottles and other relics of the British holiday-maker. The state of one of the most ancient and interesting of our monuments is said to be far worse than it was fifteen years ago, and there is nobody at present to look after it.

According to Mr. W. C. Wilkinson, of New York, there is a lamentable decay of what he calls "the reading habit" of the American community. He has addressed to the *Nation* a letter in which he says that if the census taken could next year require people everywhere to name the books they had read during the previous twelve months, the result would probably show that not one person in a hundred in the United States had been the reader of even a single book. Some time ago Mr. Wilkinson took a leisurely drive from the Hudson to the Genesee, "through one of the most enlightened and most thriving belts of country in the Empire State of the Union," and during the journey he tried in various ways to find out from a considerable number of people the nature and extent of their recent familiarity with books. "I found the fact superfluously made out," he says, "that, so far at least as rural regions may be taken to represent in this respect the country at large, not many persons in comparison to the whole number of our population are book-readers."

The *Century Magazine* for October contains some interesting reminiscences of Sir John Herschel by the late Miss Maria Mitchell, who, during her visit to England in 1857, was for some time his guest. "I could scarcely believe," she says, "when I saw Sir John Herschel in his family, guessing conundrums with the children, playing at spelling, and telling funny anecdotes, that he was the same man of whom one had said to me when I first landed in England, 'He is living at Hawkhurst, not very well, and not very good-natured.' Probably the expression on his countenance of physical suffering had been mistaken for ill temper. He was remarkably a gentleman; more like a woman in his instinctive perception of the wants and wishes of a guest." Sir John told "pleasant little anecdotes of some self-made astronomers who came to him with most absurd notions, such as the non-existence of the moon—founded upon the reading of his works! And one good soul sent to him to have a horoscope cast, and inclosed a half-crown. Another wrote to him asking, 'Shall I marry, and have I seen her?'"

An ethnographical work on the Caroline Islands, by J. S. Kubary, is about to be published, in three parts, at Leyden. The full title is "Ethnographische Beiträge zur Kenntnis des Karolinen Archipels." The work is said to present the results of much observation and study, and it will contain many illustrations prepared from the author's original sketches.

In the new number of the *Internationales Archiv für Ethnographie* (Band ii. Heft. iv.), Dr. Luschan concludes his valuable and interesting paper on the Turkish "Schattenspiel," and Dr. O. Schellong gives a graphic account of the so-called Barlum Festival in Kaiser Wilhelm's Land. Dr. Schellong's paper is an important contribution to our knowledge of the customs of the Melanesians.

According to the scheme adopted by the Italian Royal Commission to commemorate the work of Columbus, a "Raccolta Colombiana" will be published, in six volumes, devoted to (1) the writings of Columbus; (2) Columbus and his family; (3) the discovery of America; (4) navigation and cartography of the discovery; (5) monographs (Italian precursors and continuers of the work of Columbus); (6) bibliography. This work will apparently be the outcome of a large amount of diligent research.

The Congress on Education, organized under the patronage of, and with a subvention from, the Paris Municipal Council, has concluded its sittings. It was attended principally by teachers, and there were nearly as many women as men. A considerable number of Russian and Polish teachers were present, together with a few delegates from Belgium, England, Italy, and Switzerland. The tone of the debates soon rendered it evident (the *Times* Correspondent says) that by free education the Congress meant freedom from clerical and official control. The general spirit animating the Congress was well expressed by the resolutions carried. The first was to the following effect:—"That public education should have for its object the perfecting of society by the integral culture of man; it should have a scientific character, and should employ the experimental and deductive methods of observation; it should aim at preparing mankind, from a moral, social, industrial, and agricultural point of view, for a better future, and a state of society where inequality and injustice, privileges and the exploitation of man by man, ignorance and superstition, will tend more and more to disappear. By integral education it is meant that all forms of instruction shall be equally accessible to all pupils, whether rich or poor." The Swiss delegate explained that in several cantons the pupils had free meals as well as free education. In the governing of educational matters the Congress thought there was danger in allowing any one particular class of interests to predominate. Parents especially were looked upon with suspicion as being too often opposed to progress, which was more likely to be initiated by the school teachers, the municipalities, or the State. The Congress voted that these four elements should together decide educational matters. It also pronounced itself in favour of mixed schools, where boys and girls should work side by side at the same lessons, and be sometimes taught by men and sometimes by women. A great deal of evidence was given to show that this developed the spirit of emulation and produced a higher tone of morality than the separate system. Mme. Héliga Löwy gave a pathetic account of the tyranny prevailing in Russian Poland, where boys were flogged and expelled from school if overheard speaking their native language, and explained the measures taken by the Russian Government to prevent the growth of education, quoting an official decree stating that knowledge spread too rapidly among the people, and that this menaced social order.

At the Sanitary Conference at Worcester last week a very interesting paper on sewage and fish was read by Mr. Willis Bund, a well-known barrister and authority on inland fishery matters, and Chairman of the Severn Fishery Board. His suggestion was that the standard of purity for effluents from sewage works should be that the effluent should be purified to such an extent that no effect would be produced upon fish that frequented the stream into which the effluent flowed. Incidentally Mr. Willis Bund gave much interesting information on fish and sewage in this country. Dividing the rivers of the country into those in which *Salmonidæ* are found and those where they are not, he said that curiously enough, up to the present time, with one exception (York), all sewage works had been placed on rivers from which *Salmonidæ* were absent. It had for a long time been the fashion to say that the effluent from sewers did not injure fish life, because fish were often seen feeding at the sewers' mouths, but fresh sewage was limited, and the class of fish usually found near sewers and drains were known as coarse or white fish—roach, dace, chub, &c.; but it was a fact that the *Salmonidæ* did not feed at the entrance to sewers, and were not found there. Speaking broadly, he said the fish that inhabit the English rivers are divided into two great classes—*Cyprinidæ*, or fish of the carp family, and *Salmonidæ*, or fish of the salmon family. The first are resident in fresh water; the latter comprise migratory species. The first are far more tenacious of life than the second, and will live and even thrive under circumstances in which the second would die at once. Curiously enough, sewage experiments have been made almost exclusively on members of the *Cyprinidæ*, and usually on fish that are the hardiest and most difficult to kill of that family; and yet more curiously, the fish usually selected for experiment is a fish not indigenous to British waters, but one of the hardiest of all the *Cyprinidæ*—the gold-fish. It is difficult to say what amount of impurity a gold-fish will not live in. Yet it is on this fish that the experiments of the effect of sewage and impure effluents are usually made, probably because the gold-fish can be bought more cheaply and more easily than almost any other live fish. Hitherto the rivers on which sewage works had been erected had either had no fish at all in them or had had the hardiest member of the *Cyprinidæ*. He thought that those who were interested in river pollution would be doing useful work by preparing a classified list of the rivers of England and Wales, thus—(*a*) rivers not containing fish ; (*b*) rivers containing *Cyprinidæ* only ; (*c*) rivers containing *Cyprinidæ* and non-migratory *Salmonidæ* ; (*d*) rivers containing migratory *Salmonidæ*. For each class a minimum standard of purity should be agreed to.

THE Ceylon papers announce the death of an elephant named Sella, which had served the Public Works Department for over sixty-five years. Originally Sella belonged to the last of the Kings of Kandy, Sri Wickrema Raja Singha, and was one of about 100 elephants which passed to the British Government in 1815, when the Kandyan dynasty was overthrown and the whole island passed under British rule. It was supposed at that time that Sella was fifteen years of age, but this was uncertain. In 1880 it was decided that all the elephants belonging to the Public Works Department should be sold, and Sella fell to a well-known resident of Colombo, Mr. de Soysa. The animal aided in several *keddah* operations for the capture and taming of wild elephants, but became totally blind about three years ago. He continued, however, to work at the plough until within a short time of his death. After death the tusks were removed, and measured 5 feet in length. Sella himself was 8 feet high.

THE autumn gathering organized by the promoters of the University Extension Scheme in Edinburgh began on the 24th ult., and it will go on till October 5. The objects of the gathering are officially stated to be to make known the advantages of the University Extension Scheme, to afford to those who have not received a University education some experience of University life and practice, and to consider the propriety of organizing "reading centres" in Scotland in connection with the National Home Reading Union. The promoters have been fortunate in securing the assistance of some of the most eminent literary men and men of science in Edinburgh, including Profs. Masson, Tait, Crum Brown, Cossar Ewart, and Geikie ; while the syllabus offers a very attractive programme in the five departments of physical science, biological science, political science, history and ethics, literature and art and music. There are forty-five lecturers in all, and the lectures, numbering upwards of fifty, will be delivered on nine days. The opening lectures on the 24th, by Profs. Kirkpatrick and Crum Brown, were attended by about 100 persons, and Prof. Tait at his lecture on Wednesday had an audience of some 200, and on all these occasions the larger proportion were ladies.

THE twelfth annual meeting of the Midland Union of Natural History Societies was held in Oxford on the 23rd and 24th ult. The visitors, who were rather numerous, met the Oxford Society at the University Museum in the Parks at half-past one o'clock on Monday. The company was divided into small parties, who were conducted to the various places of interest. The annual meeting followed, under the presidency of Mr. E. B. Poulton, F.R.S., who subsequently delivered the Presidential address, taking for his subject "Heredity." In the evening a *conversazione* was held, at which about four hundred persons were present, including all the leading members of the University now in Oxford. The large lecture-room of the Sheldonian Theatre was crowded with an audience to hear Dr. Tylor's description of the savage methods of obtaining fire. Sir Henry Acland afterwards made a brief speech, pointing out the great progress which science had made in Oxford. Many objects of interest were also exhibited, including some specimens of sand grouse, and specimens of the whole of the grasses of Oxfordshire. Mr. H. Balfour explained the principal objects in the Pitt-Rivers anthropological collection in the Museum, and Mr. Poulton described the local specimens of geology. The afternoon of the second day was spent at the Radcliffe Observatory.

PROF. GIGLIOLI was the delegate for Italy to the Ornithological Congress held at Vienna, in 1884, under the presidency of the late Crown Prince Rudolph of Austria—a Congress at which, the *Times* report stated, "England was conspicuous by its absence." The subjects which the programme of this Congress set forth were of so trivial a nature that it is scarcely to be wondered at that English ornithologists, who seem to fight shy of Congresses as a rule, scarcely deemed it worth while to journey to Vienna to discuss such problems as the origin of the common fowl, &c. Nevertheless, the results of that Congress were really of great importance. Not only were several first-class memoirs presented to the meetings, but the institution of an International Committee for the purpose of creating stations of observation on the distribution and migrations of European birds was a distinct step in advance, and had no more important work than that of Prof. Giglioli resulted from this determination, it would alone have justified the meeting of the Congress. As a matter of fact, however, these *réunions* of zoologists, such as the one that has just taken place in Paris, are the means of bringing together men who might not otherwise meet; and as a vehicle for the interchange of ideas, and of forming acquaintances which result in the permanent benefit of the institutions to which the Congressmen belong, they are to be greatly encouraged. Prof. Giglioli was appointed, on his return, official ornithologist for Italy by the Minister of Agriculture, Industry, and Commerce, and he at once enlisted a valuable corps of coadjutors in different parts of the Italian peninsula, and the records of these observers are now presented to us in a substantial volume which is entitled "Primo resoconto dei risultati della inchiesta ornitologica in Italia." A map of Italy, which accompanies the volume, marks the places where observations have been made—about 200 in number, with nearly 300 observers. Taking, therefore, his own "Avifauna Italica" as a groundwork, Prof. Giglioli follows the same order in making his record of observations, so that anyone studying the birds of Italy can find out exactly what has been done in the way of discovery since the appearance of the above-mentioned work—an admirable advantage to the student of geographical distribution.

THE University College of North Wales has issued its Calendar for the year 1889–90.

THE additions to the Zoological Society's Gardens during the past week include a Red-handed Tamarin (*Midas rufimanus*) from Surinam, presented by Miss Gladys E. Meyrick ; two Black-footed Penguins (*Spheniscus demersus*) from South Africa, presented by Mr. Harding Cox, F.Z.S. ; a Peregrine Falcon (*Falco peregrinus*) captured in the Red Sea, presented by Mr. T. J. Taylor ; a Common Pintail (*Dafila acuta*), European, presented by Mr. R. Terrot ; a Himalayan Bear (*Ursus tibetanus*, ♂) from Northern India, two Common Cassowaries (*Casuarius galeatus*) from Ceram, a Laughing Kingfisher (*Dacelo gigantea*) from Australia, deposited ; six Californian Quails (*Callipepla californica*, 2 ♂ 4 ♀) from California, purchased ; a Malaccan Parrakeet (*Palæornis longicauda*, ♂) from Malacca, a Malabar Parrakeet (*Palæornis columboides*, ♂) from Southern India, a Californian Quail (*Callipepla californica*, ♂) from California, a Virginian Colin (*Ortyx virginianus*, ♂) from North America, received in exchange ; four Long-fronted Gerbilles (*Gerbillus longifrons*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

Mr. Tebbutt's Observatory, Windsor, New South Wales.—Mr. Tebbutt, who, it will be remembered, published a short account of his observatory about a year and a half ago (Nature, vol. xxxvii. p. 400), has resolved to supplement it by a brief annual report, the first of which reports, that for 1888, he has now just issued. The record of his work during the year shows him to have been fully as active as formerly; the list of observations, including, in addition to routine meridian and meteorological work, 56 occultations of stars, besides those of Venus and Saturn, the occultation of 47 Libræ by Jupiter, 75 phenomena of Jupiter's satellites, 230 comparisons of Jupiter and β^1 Scorpii at their conjunction; 164 observations of Pallas on 17 nights, 215 of Comet Sawerthal on 23 nights, 63 of Encke's comet on 10 nights, and 187 of Comet Barnard (1888, September 2) on 20 nights, besides measures of 24 double stars. Faye's comet was seen on December 3, but no determination of place was obtained. The whole of the observations were made by Mr. Tebbutt himself, who has a well-earned reputation for accuracy, and it is with a just and natural satisfaction that he alludes to the use made of his observations by Dr. Kreutz in his discussion of the orbits of the comets of 1880 and 1882, and by Von Haerdtl of that of Winnecke's comet. During the present year, 1889, Mr. Tebbutt proposed to continue observations of the same nature as in 1888, with especial attention to lunar occultations.

The Variable η Argûs.—Mr. Tebbutt mentions in his report the recent increase in light which has been shown by η Argûs, and to which he had already called attention in the *Astronomische Nachrichten*. Dr. Thome now supplements this statement in the same publication, No. 2922, in which he gives the Cordoba observations of the star. From these it appears that the star ran steadily down in brightness from 1871 to 1887, and that since then there has been a fairly rapid recovery, also steady in character. The star has at the same time shown a remarkable change as to colour: before minimum it was a dull scarlet, now it is bright orange; indeed it was the change in colour rather than any increase in brightness which first attracted Dr. Thome's attention. This change he first noticed on March 20, 1887; the last observation previous having been made in July 1886, from whence he infers that minimum fell about October or November 1886. "But if," he adds, "we have here, as seems probable, a type of Mr. Lockyer's binary meteor swarms, March 20 would correspond nearly with the beginning of collisions, and opposition may have occurred years earlier." Dr. Thome estimates the minimum brightness as 7·65; taking the maximum brightness in 1843 as − 1·0 mag. (between Sirius and Canopus), the total range will be 8½ magnitudes in a period of forty-three or forty-four years.

Dr. Thome considers that the observations since 1811, if reduced to the same scale, might no longer show secondary maxima.

The Rotation Period of the Sun.—Mr. Henry Crew, who published about eighteen months ago (Nature, vol. xxxvii. p. 495) a determination of the rotation period of the sun by means of the relative displacement of lines in the solar spectrum when observed at the east and west limbs, has recently undertaken a fresh series of observations for the correction or confirmation of those made last year. It will be remembered that Mr. Crew found that his earlier observations gave an increase in the angular velocity with increase of latitude, in opposition to the results obtained by Carrington and others from the observation of sun-spots, and which showed the greatest angular velocity for the equator and its neighbourhood. Mr. Crew now finds that his earlier result needs revision, for there was apparently a systematic error connected in some way with the date of observation. The new series, however, still points to a shorter rotation period for the higher latitudes, the mean value for the rotation period at lat. 45° being 18 hours shorter than at the equator. Having regard to the smallness of this amount and the uncertainty of the observations, Mr. Crew concludes that "no certain variation of period with latitude has been detected by the spectroscope." He calls attention, however, to the wide difference in the values of the equatorial period as obtained by different methods. Hornstein and others, from the variations in the daily range in the barometer, fixed the sidereal rotation period as 24·12 days; Braun and Hornstein, from the variation of the magnetic elements, deduced the values 24·18 and 24·51 respectively; Carrington obtained from sun-spots 24·97 days; Wilsing, from faculæ, 25·23; whilst Crew's value from the spectroscopic method is the longest of all—26·23 days. Mr. Crew makes the suggestion that the different methods really deal with different strata of the sun, and that those portions of the sun which affect the variations of the barometer and of terrestrial magnetism are more deeply seated than the sun-spots, which, again, lie lower than the faculæ, the angular velocity of rotation diminishing on this view from the more central portions of the sun outwards.

Comet 1889 *d* (Brooks, July 6).—The following elements for this comet have been derived by Dr. Otto Knopf from observations made at Mount Hamilton on July 8, Dresden July 30, and Vienna August 19:—

T = 1889 September 26·9997 Berlin M.T.

$$\left.\begin{aligned} \pi - \Omega &= 341^\circ\ 56'\ 26''\cdot 6 \\ \Omega &= 18\ 14\ 21\cdot 2 \\ \iota &= 6\ 3\ 24\cdot 0 \end{aligned}\right\}\ \text{Mean Eq. } 1889\cdot 0.$$

$$\phi = 28\ 33\ 52\cdot 4.$$

$$\log q = 0\cdot 292550 \qquad \log a = 0\cdot 575004.$$

$$\mu = 486''\cdot 969 \qquad \text{Period} = 7\cdot 286 \text{ years.}$$

Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log Δ.	Log *r*.	Brightness.
Oct. 4	23 45 57	4 53·6 S.	9·9937	0·2928	2·5
8	23 44 5	4 39·9	0·0003	0·2931	2·4
12	23 42 35	4 24·0	0·0081	0·2935	2·3
16	23 41 28	4 6·1	0·0172	0·2941	2·2
20	23 40 48	3 45·9 S.	0·0273	0·2948	2·1

The brightness at discovery has been taken as unity.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 OCTOBER 6–12.

(For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on October 6

Sun rises, 6h. 12m.; souths, 11h. 48m. 2·1s.; daily decrease of southing, 17·3s.; sets, 17h. 25m.: right asc. on meridian, 12h. 49·3m.; decl. 5° 18′ S. Sidereal Time at Sunset, 18h. 27m.

Moon (Full on October 9, 1h.) rises, 17h. 5m.; souths, 22h. 17m.; sets, 3h. 42m.*: right asc. on meridian, 23h. 20·0m.; decl. 9° 26′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° ′
Mercury..	8 6	12 50	17 34	13 51·8	15 10 S.
Venus ...	3 5	9 51	16 37	10 52·3	8 25 N.
Mars ...	2 46	9 40	16 34	10 41·3	9 42 N.
Jupiter ...	13 11	17 3	20 55	18 5·0	23 30 S.
Saturn ...	2 0	9 9	16 18	10 9 9	12 41 N.
Uranus...	6 57	12 20	17 43	13 21·5	7 58 S.
Neptune..	19 22*	3 11	11 0	4 10·8	19 22 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Saturn, October 6.—Outer major axis of outer ring = 37″·9; outer minor axis of outer ring = 6″·3: southern surface visible.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	Oct. 10,	3 6	*m*
Algol	3 1·0	40 32 N.	,, 7,	0 33	*m*
			,, 9,	21 22	*m*
λ Tauri	3 54·5	12 11 N.	,, 8,	23 51	*m*
ζ Geminorum	6 57·5	20 44 N.	,, 8,	23 0	*m*
R Ursæ Minoris	16 31·5	72 30 N.	,, 8,		*m*
R Draconis	16 32·4	66 59 N.	,, 9,		*m*
U Ophiuchi	17 10·9	1 20 N.	,, 9,	22 24	*m*
R Lyræ	18 52·0	43 48 N.	,, 6,		*m*
S Vulpeculæ	19 43·8	27 1 N.	,, 11,		*M*
U Cygni	20 16·2	47 33 N.	,, 9,		*m*
X Cygni	20 39·0	35 11 N.	,, 10,	2 0	*M*
T Vulpeculæ	20 46·8	27 50 N.	,, 9,	20 0	*m*
			,, 10,	22 0	*M*
W Cygni	21 31·8	44 53 N.	,, 12,		*M*
δ Cephei	22 25·1	57 51 N.	,, 6,	3 0	*m*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near γ Persei	44 ...	54 N. ...	Slow.
	103 ...	33 N. ...	Swift; streaks.
	135 ...	80 N. ...	Very swift.

GEOGRAPHICAL NOTES.

THE Hon. Secretary of the South Australian branch of the Geographical Society recently received the following telegraphic message from Mr. Tietkens, who is in command of an Expedition engaged in exploring the interior. The telegram came from Charlotte Waters, and is published by the *Colonies and India*. It says:—"The Expedition under my command arrived at Erldunda on July 22, the party being all well. The Expedition left Glen Edith on May 10. While there for four days and five nights almost incessant rain fell. Forty miles west of Glen Edith we discovered and named Cleland Hills and Gill's Creek, flowing south for twelve miles. The extent of good country is limited. We also discovered and named Beetson Hills, where there were three miles of running water, the extent of available country also being limited. In east longitude 128° 45′ and south latitude 23° 20′, we discovered and named the Kintore Range, the highest peaks of which are Mount Leister and Mount Strickland, 1500 feet above the plains. Here we experienced three days' heavy rains. In south latitude 23° 22′ and east longitude 128° 15′, we discovered and named Lake Macdonald, after the hon. secretary of the Victorian branch of the Society. It extends westerly to east longitude 127° 50′, the south shore being in latitude 23° 40′. South of the Kintore Range we visited and named Davenport Hill, and thence we travelled in a south-easterly direction to Blood's Range, the highest peaks of which were named Mount Harris and Mount Carruthers, being 1400 feet above the plains. Mount Unapproachable, in Long's Range, marks the west extremity to Lake Amadeus, its south shore, south of Mount Olga, being in latitude 24° 39′. At Lake Amadeus the camels partook of a poisonous plant, from the effects of which one died. At Mount Olga the other was unable to travel. After a week's rest the Expedition left there and visited Ayer's Rock. Mr. Goss's marked tree has been burnt down by the blacks. Near Mount Connor we discovered a small spring, and travelling northward from there discovered and named Basedow Range; from there travelled easterly over better country until we arrived here, receiving a most cordial and hospitable reception from Messrs. Warburton and Tomlin. To Mr. Warburton's kindness we are indebted for conveying this message to the telegraph line. The general character of the country passed over has been Spinifex, sand-hills, and plains, with extensive forests of Casuarina. Rock reservoirs, native wells, and a few clay-pans were the only descriptions of water met with."

ONE of the most important of recent exploring Expeditions has been that under Sir William Macgregor, the Administrator of British New Guinea, who has recently ascended and examined the Owen Stanley Range, over 13,000 feet above the sea. Several attempts have been made to reach the summit within the past few years; Sir William therefore deserves much credit, all the more that his natural history observations are very full and valuable. Sir William is an accomplished naturalist, so that any exploring work he may undertake is sure to be of scientific value. He left Port Moresby in May, accompanied by his secretary, and when the Expedition was finally made up there were about forty natives. Only five, however, went up to the top with Sir William, who spent three or four days examining the ridge. The summit was reached on June 11. The climate Sir William describes as foggy and unpleasant up to 8000 feet; but above that clear blue sky and beautiful climate, "one of the finest in the world." The party were ten days over 10,000 feet, and never had a cloud above them. The sea coast was visible on both sides, that on the north being the most distant. But the country is much smoother on that side, and the ascent of the mountain from the north apparently unobstructed and easy. From the point of Mount Victoria in the east to Mount Lilley in the west is a continuous, unbroken crest of thirty miles, which was traversed by Sir William, who spent three days and a half on the summit. His eyes were gladdened by the sight of daisies, buttercups, and forget-me-nots, and he brought away with him a quantity of white heath which reminded him of his native mountains. Big icicles amazed his native companions, who thought their mouths were burnt when they attempted to bite this, to them, novel product of Nature. Larks were plentiful, similar in flight and song to those of the old country. Specimens of the flora were naturally collected by an enthusiastic naturalist like Sir William, and amongst them also probably several novelties will be found. There are no trees within 1000 feet of the top, which is bare rock or covered with grass. There are no snakes or other pests on the main range, but unfortunately game is very scarce also. The temperature ranged from freezing-point to 70° in the sun. The southern aspect of the range is drained exclusively by the Vanapa River, the head of which was crossed at an elevation of 10,130 feet. No natives live on the mountains above 4000 feet, although they hunt as high as 9700 feet. All those met with at the base were extremely friendly. Nothing, however, would induce any of them to accompany the party up the mountain. They grow tobacco, peas, beans, many kinds of potatoes, yams, and bananas, and of these they gave Sir William as much as he wanted. They are certainly Papuan. The party returned to Port Moresby on June 25. Sir William was in perfect health the whole time, though, as usual, the natives had their little complaints. Another account states that Sir William found the top of the crest very uneven, consisting of immense masses of rock separated by deep chasms. The long-tailed bird of paradise was shot at from 5000 to 9000 feet altitude. On the top of one of the mountains what is believed to be a new bird of paradise was obtained, golden yellow on the back, with a black velvet breast and belly. As to the botany, the variety was very small, but what there was was new.

M. YADRINTZEFF's Expedition returned to Kiakhta on August 16, after having reached the sources of the Orkhon River, and determined the position of Kara-korum. It also discovered the ruins of two large cities (one of them having a circumference of thirteen miles), as well as of the palaces of the Khans of Mongolia, and their cemeteries, where numerous statues and important inscriptions were found.

THE BRITISH ASSOCIATION.

REPORTS.

Report (Eighteenth) of the Committee appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water. Prof. Everett, Secretary.

Very important observations have been published (*Neues Jahrbuch für Mineralogie*, &c., 1889, Bd. 1) during the past year by Herr Dunker, whose observations in a very deep bore at Sperenberg were embodied in our Report for 1876. The new observations were taken at Schladebach, near Dürrenberg, in a bore of greater depth and smaller diameter than at Sperenberg, and with similar precautions against convection currents. The depth was 1748 metres, the bore passing through new red sandstone (Buntsandstein), magnesian limestone (Zechstein), Lower Permian sandstone (Rothliegendes), and coal-measures (Steinkohlengebirge), to the Upper Devonian beds (Oberdevon).

It was tubed to the depth of 1240 metres. For the first 584 metres the diameter was 120 millimetres; for the next 104 m. it was 92 mm.; then for 393 m. it was 72 mm.; and for the next 159 m. it was 50 mm. From this point to the bottom the diameter gradually diminished to that of a man's little finger. The diamond borer was the instrument employed in sinking it.

India-rubber bags, such as were used at Sperenberg for preventing convection currents, being deemed unsuitable for such a narrow bore, a plugging of moist clay was employed, constructed as follows:—

On a cylindrical rod, which might be of tough wood for bores of moderate depth, but was of iron in the actual observations, are two wooden disks of such size that there is only just room for them to move in the bore. The lower disk is fixed, and the upper movable on the rod. The part of the rod below the fixed disk has a length equal to that of the water-column which it is desired to isolate. The maximum thermometer with which the temperatures are taken has its bulb half-way down this portion of the rod. It is fastened beside the rod if there is room for it; and when the bore is too narrow for this arrangement, the thermometer is placed in a metal box which may be described as forming part of the rod, the rod being divided into two portions screwed to the two ends of the box. The movable disk is removed to a measured distance from the fixed one, and the space between them is then filled with clay which has been made plastic by kneading it with water, so that it forms a cylinder with the two disks.

When the pole presses on the bottom of the bore, part of the weight of the boring rods is supported on the upper disk, thus squeezing the clay against the sides of the bore and forming a water-tight plug.

The above description applies especially to the taking of observations at the bottom of the bore. When it was desired to isolate a column of water at a considerable distance from the bottom, the apparatus employed consisted of two portions. The above description applies to the upper portion, and the lower portion was similar to it but inverted, resting upon rods which extended to the bottom. The two masses of clay in this case cut off a water-column between them.

Experiments with a model, in which the bore was represented by a cylindrical glass vessel 26 cm. high and 55 mm. wide, filled with water, showed that the isolation was very good, and that it remained so though the immersion lasted more than ten hours. In tearing away the clay from the vessel a portion of the clay fell into the water, but such an accident occurring in the bore would be of no consequence.

The construction of the isolating apparatus was intrusted to Bore-Inspector Köbrich, under whose management the observations were to be carried out.

Besides the thermometer in the isolated water-column, there was a second maximum thermometer in the open water just above the upper plug, for comparison, the height of its bulb above that of the principal thermometer being 2·8 m.

The thermometers were very similar to those employed at Sperenberg. They were overflow-thermometers, generally without scales, and were inclosed (for protection against pressure) in a hermetically sealed case of stout glass with an external diameter of 15 mm. To take the reading, the thermometer, after being drawn up, was put with a normal thermometer into a vessel of water at a temperature a little below that which was expected. Warm water was then gradually added, and the whole kept stirred till the mercury in the overflow-thermometer reached the open end. The temperature at this moment was then read by the other thermometer.

The first observations taken were in the untubed portion of the bore, which at that time extended from the depth of 1240 m. to 1376 m.; and as the bore was deepened to 1748 m. the observations were continued. In this way the last sixteen observations of Table I. were obtained, forming a series at intervals of 30 m. from 1266 m. to 1716 m. of depth.

A pause which subsequently occurred in the sinking of the bore, through having to wait for a new tube, was utilized for taking the observations which form the remainder of the table. We have thus a complete series of observations, at equal intervals of 30 m., from the depth of 6 m. to that of 1716 m.: 8°·3 R. at 6 m., and 45°·3 R. at 1716 m.

The table is arranged in five columns. The first column contains the natural numbers from one to fifty-eight, for convenience of reference to the observations at the fifty-eight different depths; the second column contains the depths in metres; and the third column, the temperatures observed at these depths in isolated water-columns. The fourth column contains the excess of the temperature so observed above the temperature observed by means of the secondary thermometer in the free water just above the plug. The fifth column contains the differences between the successive numbers in the third column—in other words, the increase of temperature for each 30 m. of depth.

The smallness of the effect of isolation, as shown in the fourth column of the table, is very noteworthy, its greatest value being 1° R., and its average value about ¼ of 1° R. At Sperenberg it amounted in several cases to about 3° R. The smallness of the effect in the present case is attributable to the narrowness of the bore, which tells in two ways: there is more frictional resistance to the movement of the water; and the thermal capacity of a given length of column is less in comparison with its surface of contact with the sides of the bore.

As a further experiment on the prevention of convection, a wooden plug was driven into the bore at the depth of 438 m., thick mud was introduced till it filled all the bore above this plug, and observations were taken with a maximum thermometer in the mud at depths from 426 m. to 126 m. A second plug was then driven in at the top of the tubing, which was 120 m. beneath the surface of the ground, and the observations were continued upwards from 118 m. to 6 m. The observations thus taken in the mud are given. They are rather higher than those previously obtained at the same depths, the greatest difference occurring at the depth of 276 m., where it amounts to 0°·9 R. Herr Dunker suggests that the difference may have arisen from insufficient time being allowed for the mud to take the permanent temperature.

Upon the whole it is clear that in this great bore the disturbing effect of convection is very small, and that, such as it is, it has been almost annihilated by the very efficient system of plugging adopted. The series of observations now before us, extending as it does by regular stages from the surface to a depth of 5630 feet, in a new bore where there has not been time for the original heat to be lost by exposure, forms undoubtedly the most valuable contribution ever made to the observation of underground temperature. The official to whose initiative the observations are due is Chief-Mining-Captain Huyssen, of Berlin. The expense of sinking the bore was £10,000 sterling, the time required for hauling up the boring rods was ten hours, and their united weight was 20 tons.

On plotting the temperatures so as to exhibit temperature as a function of depth, the curve obtained approximates very closely to a straight line. A straight line joining its two ends meets the curve several times in the part corresponding to the tubed portion of the bore, which is about three-fourths of the whole; while in the remaining fourth (forming the deepest portion of the bore) all the temperatures except the first and last lie above the straight line. In this statement it is to be understood that depth is represented by distance laid off horizontally, and temperature by distance laid off vertically upwards.

The question whether the curve on the whole bends upwards or downwards is of some interest, because it is equivalent to the question whether the rate of increase is accelerated or retarded as we go deeper. The evidence on this point is undecisive. The curve for the untubed portion, from 1266 m. to 1716 m., lies slightly above its chord; but the curve from either 6 m. or 36 m. to 1500 m. lies for the most part below its chord.

Taking the observation at 36 m. as the first which is free from atmospheric disturbance, and comparing it with the deepest observation of all, which is at 1716 m., we have an increase of 36°·5 R. in 1680 m. This is a difference of 82°·1 F. in 5512 feet, which is at the rate of 1° F. in 67·1 feet.

Herr Dunker, after an elaborate discussion of the question whether the curve on the whole bends upwards or downwards, arrives at the conclusion that it is best represented by a straight line. He applies the method of least squares to find the slope of this straight line, on the assumption that it passes accurately through the point determined by the observation at 36 m., and he thus obtains a mean rate of increase of 0·0224276 of a degree Réaumur per metre, which is equivalent to 1° F. for 65·0 feet.

The Secretary has been in correspondence with Mr. George Westinghouse, Jun., of Pittsburg, President of the Philadelphia Company, with the view of obtaining observations of temperature from some of the deep oil and gas wells belonging to the Company. Mr. Westinghouse has purchased three of the Committee's maximum thermometers, and has intrusted the taking of the observations to Mr. A. Cummins, the Company's Mining Engineer and Geologist. Some attempts have been made at observation, but owing to press of business they have not been thoroughly carried out. Mr. Cummins states that "there has been a constant strain to bring up the supply of gas to the requirement of the city's needs, and every hour of delay is watched very jealously."

The most successful attempt was made in a well at Homewood, in the city of Pittsburg, known as the Dilworth well, where the following results were obtained:—

Depth in feet.	Temperature F.	Air at surface.
	°	°
3600	96	70
3710	89	76
3920	102	60
4002	108	62
4215	111	62
4295	114	62

The well was sunk to a depth of 4625 feet, but no observations were made except at the depths specified. The thermometer remained only from five to ten minutes during each test; and as there were only 40 feet of water in the well, the observations must have been taken in air. The diameter of the well was 6 inches. The rock was chiefly slate, and was bored by "jumping." The mean air temperature at Pittsburg is 52° F., and the height above sea-level about 900 feet. Comparison of the mean surface-temperature (taken as 52°) with the temperature 114° recorded at 4295 feet shows an increase of 62°, which is at the rate of 1° F. for 69·3 feet; but comparisons of the observations *inter se* would give a rate about twice as rapid as this; hence no safe conclusion can be drawn. After the hurry and worry of the gas business is over, Mr. Cummins hopes to get the temperature of some deep wells in a way that will be satisfactory.

We may mention, as a contribution to the literature of underground temperature, the recent publication of results obtained at the Old Observatory, Allahabad, with thermometers whose bulbs were at the depths 3 feet, 1 foot, and ½ inch respectively. Harmonic reduction has been applied to deduce both the annual and the diurnal variation, and from the former a fairly consistent determination of "diffusivity," or quotient of conductivity by capacity, has been obtained. Its value, 0·0054 C.G.S., is smaller than any values that have been found elsewhere. The soil is a sandy loam, which in dry weather becomes almost as hard as brick. The observations extend over six years, and similar observations are now being carried on at the New Observatory. The gentleman who is responsible for the reductions and the description of the observations is Mr. S. A. Hill, B.Sc., Meteorological Reporter to the Government for the North-West Provinces.

Report of the Committee appointed for the purpose of investigating the Best Methods of ascertaining and measuring Variations in the Value of the Monetary Standard. Prof. Edgeworth, Secretary.

This consists of a Supplementary Memorandum by the Secretary, designed as a supplement to the Memorandum appended to the First Report of the Committee. The object of that Memorandum was to distinguish the different definitions which the proposed problem might present; and to construct the formula appropriate to each phase of the investigation. The analysis of contents is as follows:—(1) Prof. Newcomb's method; (2) Prof. Foxwell's method; (3) Mr. Giffen's methods; (4) Mr. Bourne's method; (5) Sir Rawson Rawson's method; (6) Prof. Edgeworth's method; (7) Ricardo's method.

The conclusion of the Memorandum runs as follows:—

It may be useful to enumerate and summarily characterize the principal definitions of the problem, or "standards,"[1] which have been discussed in this and the preceding Memorandum. An alphabetical order will be adopted, the order of merit being not only invidious, but also impossible in so far as different methods are the best for different purposes.

1. The *capital standard* takes for the measure of appreciation or depreciation the change in the monetary value of a certain set of articles. This set of articles consists of all purchasable things in existence in the community, either at the earlier epoch or at the later epoch, or some mean between those sets. This standard is due to Prof. Nicholson. It is stated by him (in terms a little less general than those here adopted) in his book on "Money." It is discussed in the sixth and the tenth sections of the former Memorandum.

2. The *consumption standard* takes for the measure of appreciation or depreciation the change in the monetary value on a certain set of articles. This set of articles consists of all the commodities consumed yearly by the community either at the earlier or the later epoch, or some mean between those two sets. This standard has been recommended by many eminent writers, in particular by Prof. Marshall in the *Contemporary Review* of 1887. It is proposed by the Committee as the principal standard. It is discussed in the second section of the former Memorandum.

3. The *currency standard* takes as the measure of appreciation or depreciation the change in the monetary value which changes hands in a certain set of sales. These sales comprise all the commodities bought and sold yearly at the earlier epoch or at the later epoch, or some mean between those quantities. This standard appears to be implicit in much that has been written on the subject, but to have been most clearly stated by Prof. Foxwell. It is discussed in the second section of this Memorandum.

[1] The methods discussed in connection with the names of Mr. Giffen, Mr. Bourne, and Sir Rawson Rawson are rather solutions than statements of the problem.

4. The *income standard* takes as the measure of the appreciation or depreciation the change in the monetary value of the average consumption, or in the income per head, of the community. This standard is proposed in the fourth and fifth sections of the former Memorandum.

5. The *indefinite standard* takes as the measure of appreciation or depreciation a simple unweighted average of the ratios formed by dividing the price of each commodity at the later period by the price of the same commodity at the earlier period. The average employed may be the arithmetic mean used by Soetbeer and many others, or the geometric mean used by Jevons, or the median recommended by Prof. Edgeworth. This standard is recommended by the practice of Jevons[1] and the theory of Cournot.[2] It is discussed in the eighth and ninth sections of the former Memorandum, and the fifth section of the present one.

6. The *production standard* is a designation which may be applied to a method which is related to the currency standard very nearly as the income standard is related to that based on consumption. The production standard takes as the measure of appreciation or depreciation the change in the monetary value *per head* of the total amount of things produced in the community yearly. This standard is proposed by Prof. Simon Newcomb in his "Political Economy." It is discussed in the first section of this Memorandum.

7. The *wages* (and *interest?*) *standard* takes as the measure of appreciation or depreciation the change in the pecuniary remuneration of a certain set of services—namely, all (or the principal) which are rendered in the course of production, throughout the community, during a year, either at the initial or the final epoch; or some expression intermediate between the two specified. The theoretical basis and practical construction of such a standard are indicated in Ricardo's "Principles of Political Economy" (ch. xx. and elsewhere), in Prof. Marshall's evidence before the Gold and Silver Commission ("Parliamentary Papers," 1888, C.), and in the papers contributed by Mr. Giffen to the second volume of the Bulletin of the International Statistical Institute. The standard is discussed in the last section of this Memorandum.

Report (Second) of the Committee appointed for the purpose of reporting on the present state of our knowledge of the Zoology and Botany of the West India Islands, and taking steps to investigate ascertained deficiencies in the Fauna and Flora. Mr. D. Morris, Secretary.

This Committee was first appointed in 1887, and re-appointed in 1888. At a meeting held on December 5, 1888, it was decided to invite the co-operation of Dr. Günther, F.R.S., a member of the sub-committee appointed for a similar purpose by the Government Grant Committee of the Royal Society, and Colonel

[1] Most of Jevons's celebrated calculations ("Currency and Finance," ii., iii., and iv.), and in particular his calculation of the probable error incident to his result (*ibid.* p. 157), involve this conception.

[2] Cournot has considered our problem in each of the five volumes in which he has treated of, or touched on, political economy ("Dictionary of Political Economy," Art. "Cournot"). It is sufficient here to refer to the first and the last of those works, the "Recherches" of 1838 and the "Revue Sommaire" of 1876—the Alpha and almost the Omega of economic wisdom. From these it is clear that variation in the "absolute" or "intrinsic" value of money, in Cournot's view, corresponds to the "indefinite standard" as defined in Section viii. of the predecessor to this Memorandum. Cournot illustrates the variation due to a change on the part of money, by that change in the position of the earth with respect to the stars, which is due to the motion of the earth. In this analogy the stars are treated as "points" ("Recherches," Art. 9). No account is taken of their mass. The context shows that Cournot contemplates a simple average of distances between the earth and each star; not a *weighted* average, or the distance between the earth and the *centre of gravity* of the stars. In his later works he expressly declares against, or at least thinks unbefitting highest place, the measure of what he calls the "power of money" ("Revue Sommaire," Sect. 3), that is, in our terms, the consumption standard; the analogy of which is the distance of the earth from the *centre of gravity* of the stars, or rather of certain select stars—say those which are nearest to our human sphere. The currency standard, of which the analogy is the distance of the earth from the *centre of gravity* of all stars whatever, does not seem to have been entertained by Cournot.

Cournot, alluding to Jevons's treatment of the problem in "Money," not unjustly takes him to task for not having distinguished "assez nettement" variations in the "intrinsic value of money" (of which the measure is our indefinite standard) from variations in the "power of money" (of which the measure is our consumption standard) ("Revue Sommaire," p. 121). Referring to Jevons's proposal to construct a *tabular standard of value*, Cournot expresses his approbation in words which may fittingly conclude the present study:—"Ce sont là des idées qu'il faut laisser mûrir. Quand le moment sera venu de construire effectivement *l'étalon monétaire*, les géomètres pourront y trouver une application intéressante de leur *théorie de moyennes*, telles qu'ils l'ont déjà construite pour les besoins de l'astronomie et de la physique."

Feilden, of the Army Pay Department, at that time acting as Local Secretary to the Committee at Barbados.

The services of Mr. G. A. Ramage were retained as collector at Dominica and St. Lucia, and several collections were received from him during the past year. Owing to ill-health Mr. Ramage returned to this country in June last, and he has now retired from the post of collector to the Committee. Mr. F. Du Cane Godman has generously assisted the work of the Committee by sending out, at his own expense, the well known naturalist and collector, Mr. H. H. Smith, to the Island of St. Vincent, to make collections in as many branches as possible of natural history. These collections have not yet reached this country, but it is anticipated that they will prove of considerable value.

Colonel Feilden obtained numerous botanical and zoological specimens in Barbados and the neighbouring islands. He has published a paper on the reptiles, and another on birds; papers on the Mammalia and land Mollusca will follow. He also obtained a living specimen of the green monkey of Western Africa, which has become feral in Barbados (*Cercopithecus callitrichus*). This was presented by the Committee to the Zoological Society of London.

Dr. H. A. Alford Nicholls, Local Secretary to the Committee at Dominica, has rendered valuable assistance, and he will be engaged for six weeks this autumn in exploring Montserrat and the isolated rock called Redonda, which is a dependency of Antigua.

The particulars of the collections received during the past year are as follows:—

Zoology.—The zoological specimens obtained by the Committee up to June 1889, including those collected by Mr. Ramage in Dominica and St. Lucia, have been placed in the hands of specialists for examination and determination. Mr. Oldfield Thomas has determined the Mammalia, Dr. Sclater the birds; Dr. Günther has published a paper on the reptiles, Mr. E. A. Smith three papers on the Mollusca, Mr. R. I. Pocock two on the Myriopoda and Crustacea, and Mr. Kirby one on the Phasmidæ.

Botany.—The botanical specimens collected by Mr. Ramage in Dominica and St. Lucia, up to May 1889, have been determined at Kew; the flowering plants by Mr. R. A. Rolfe, the ferns by Mr. J. G. Baker, and the cellular cryptogams by Dr. Cooke and Mr. C. H. Wright.

From Dominica about 394 species were received, of which (excluding the cryptogams) about 40 could only be provisionally determined; and of these a few, perhaps about half, are probably undescribed. The great majority belong to already well-known species, most of which were previously known from the island.

From St. Lucia about 189 species have been sent, of which (excluding the cryptogams, as before) over 30 were not determined, and possibly about half of these may prove to be undescribed. This island was less completely known than Dominica, and several additions to our knowledge of its flora have been made by Mr. Ramage. During the working up of the collections a strong affinity with Dominica, and perhaps still more so with Martinique, has become apparent. From the latter island large collections are well represented at Kew, though the materials have never been thoroughly worked up.

The specimens which it was not found possible to determine belong for the most part to large genera of woody plants, as Guttiferæ, Leguminosæ, Myrtaceæ, Myrsineæ, Laurineæ, and a few others, which renders it the more probable that a fair proportion of them may prove undescribed.

The number of novelties is perhaps not so great as was originally expected, and this may arise either from the ground having been worked over before, or, what is perhaps more probable, from the fact that a considerable uniformity prevails in the flora of this chain of islands, with a corresponding paucity in endemic types.

The Committee would draw particular attention to the botanical and zoological bibliography of the Lesser Antilles prepared under its direction, and published as an appendix to the Report for 1888. This bibliography has been widely distributed in the West Indies and in Europe, and has proved of considerable service in carrying out the objects for which the Committee was appointed.

Report (Fifth) of the Committee appointed for the purpose of considering the best means of Comparing and Reducing Magnetic Observations. Prof. W. Grylls Adams, Secretary.—The Committee report the establishment of regular magnetic observatories, where continuous photographic records of the magnetic elements are taken, at the United States Naval Observatory at Washington, and also at Los Angeles in California. The instruments used are of the Kew pattern, with the same time-scale, and the scale-coefficients for horizontal and vertical force instruments at Washington are very nearly those recommended by the Committee in their Third Report (1887), and which are in very near agreement with those at Vienna, St. Petersburg, and some other observatories. The Committee report, further, that the plan proposed by them in their Third Report for the Comparison and Reduction of Magnetic Observations, has been adopted at the United States Naval Observatory at Washington, which is now prepared to take part in the general scheme of co-operation proposed by the Committee. Copies of the photographic registers of the three elements for April 21–30, May 1–31, and for June 1–30 have been forwarded to the Committee from Washington, with tables of scale and temperature coefficients. There are also forwarded two prints showing the reduction of the declination for the year 1888, by means of a graphic composite curve, made by tracing over one another with a pantograph the daily curves of the month, and then drawing a curve through them to show the monthly means. There are also forwarded from Washington a set of prints showing the comparison of the disturbances of declination and horizontal force at Washington for ninety-nine days of 1888, and another set of prints showing the comparison of disturbances of declination on certain selected days at Washington, Los Angelos, and Toronto, all reduced to the same time-scale of 30·6 mm. for two hours, *i.e.* the time-scale of instruments of the Kew pattern. The Committee are more than ever of the opinion expressed in their Third Report, "that the establishment of regular magnetic observatories at the Cape of Good Hope and in South America would materially contribute to our knowledge of terrestrial magnetism." The Committee consider that it would be desirable to publish annually in a collected form for certain selected days the curves of the three magnetic elements, *i.e.* declination, horizontal force, and vertical force, taken at the different English and Colonial Magnetic Observatories, choosing for selection in 1888 the days for which the curves are published in the "Greenwich Observations."

Report (Fourth) of the Committee appointed for the purpose of promoting Tidal Observations in Canada. Prof. A. Johnson, Secretary.—The Committee refer to a previous Report, in which it was announced that the then Minister of Marine (the Hon. G. Foster) had directed that some preliminary investigations should be made by Lieut. Gordon, R.N., who was to put himself in communication with Prof. Darwin. The Minister, however, said that the existing expenditure on hydrographic surveys made it necessary to postpone for the time the consideration of further steps concerning tidal observations. The Committee was re-appointed last year to keep the subject before the notice of the Government, in the hope that this systematic tidal work would be begun this year. In May last an interview was obtained with the Hon. C. Tupper, the present Minister of Marine, at which Sir Wm. Dawson was present. The Minister expressed himself as entirely favourable to the institution of the proposed tidal observations, but said that the financial position as regards the expenditure on hydrographic surveys was the same as last year, and that therefore no further steps could be taken as yet in the matter. It is believed that since the interview some of the expenditure in hydrographic surveys has ceased, and as there is reason to believe that other Cabinet Ministers are in favour of the proposed measure, the Committee deem the prospects of carrying it into execution very satisfactory. There is no doubt about the anxiety of shipmasters to have the tidal investigations set on foot immediately, and the Royal Society of Canada deem the matter of such great practical importance, that at their last meeting they appointed a special Committee to give energetic support to the action of this Committee.

Report of the Committee appointed for the purpose of continuing the Inquiries relating to the Teaching of Science in Elementary Schools. Prof. Armstrong, Secretary.—This year has been one of continued depression in regard to the teaching of science in elementary schools, and of disappointment in regard to legislative action. The return of the Education Department for this year shows again a diminution in the teaching of the science subjects. The statistics of the class subjects for six years are given, and show an actual decrease in elementary science, and a comparative decrease in geography. The return of scholars individually examined in the scientific specific subjects shows an actual or relative falling off in every subject except mechanics and chemistry. The rapid and serious decrease of attention paid to these science subjects is shown by the percentage of children who have taken them, as compared with the number of scholars that might have taken these subjects, viz:—In 1882–83, 29·0 per cent.; in 1883–84, 26·0 per cent.; in 1884–85, 22·6 per cent.; in 1885–86, 19·9 per cent.; in 1886–87, 18·1 per cent.; in 1887–88, 16·9 per cent.; and it must be remembered that children who have taken two of these subjects count twice over. The Government laid upon the table of the House a new Code, which would have had a slightly beneficial effect upon the teaching of science; but it has been entirely withdrawn. The Government has introduced no Technical Instruction Bill this year—except just at the last moment—and that does not apply to "scholars receiving instruction in an elementary school in the obligatory or standard subjects prescribed by the minutes of the Education Department." It was hurried through the Committee and final stages during the last week of the session. Sir Henry E. Roscoe, however, reintroduced his Bill with some modifications, and it passed the second reading at a comparatively early period of the session; but the Government would only give facilities for its progress through the House on the understanding that very serious changes were to be made in it. As he could not accept these, it has not passed the Committee stage; and it was ultimately withdrawn. Mr. Samuel Smith has again brought in a Continuation Schools Bill; but there has been no opportunity of discussing it since the first reading, and it was therefore withdrawn. The subject has, however, grown in the estimation of the public; and the whole question of the teaching of science in State-aided schools requires to be pressed more and more upon the Legislature.

Report of the Committee on Electrical Standards. R. T. Glazebrook, F.R.S., Secretary. (Slightly abridged.)

The Committee report that the work of testing resistance coils has been continued at the Cavendish Laboratory. A table of the values found for the various coils is given. Further steps have been taken towards the construction of an air condenser. As stated in the last Report, Dr. Alexander Muirhead kindly placed at the disposal of the Committee, for the purpose of experiment, three such condensers which he had constructed. A series of tests of these condensers was carried out by the Secretary and laid before a meeting of the Committee in London on April 15. It was then decided to adopt Dr. Muirhead's form of condenser for the new instruments of the Committee, and two instruments, each having a capacity of 0·01 microfarad, have been ordered from the Cambridge Scientific Instrument Company. They are not yet finished; a detailed description of their design is therefore left to the next Report.

A second subject of investigation has been the specific resistance of copper. During the year Mr. T. C. Fitzpatrick has made a large series of experients to determine this, and the Committee desire to thank cordially those manufacturers and others who have given their assistance in this research. Before publishing his results, Mr. Fitzpatrick is desirous of experimenting on some copper which is being prepared for him by chemical means—all which has been used hitherto has been electrically deposited—and of attempting still further to purify some of the copper already in his possession. Two members of the Committee, Sir W. Thomson and Mr. Preece, were present at the recent Electrical Congress in Paris. As an English equivalent of the resolutions there passed, the Committee have adopted the following resolutions, which they hope will meet with general acceptance:—

(1) The name of the practical unit of work shall be the joule. The joule is equivalent to 10^7 C.G.S. units of work. It is the energy expended during 1 second by a current of 1 ampere when traversing a resistance of 1 ohm.

(2) The name of the practical unit of power shall be the watt. The watt is the rate of working of a machine performing 1 joule per second. The power of a machine could naturally be expressed in kilowatts instead of in horse-power.

(3) The name of the practical unit of light intensity shall be the candle.

The candle is equal to the twentieth part of the absolute standard of light as defined by the International Conference of 1884.

(4) The name of the practical unit of induction shall be the "quadrant." 1 quadrant is equal to 10^9 cm.

(5) The "period" of an alternating current is the duration of a complete oscillation.

(6) The "frequency" of an alternating current is the number of complete oscillations per second.

(7) The "mean current" through a circuit is the time average of the current, and is defined by

$$\text{mean current} = \frac{1}{T}\int_0^T i\,dt,$$

i being the current at each instant of the time T.

(8) The effective current is the square root of the time average of the square of the current. Thus

$$\text{effective current} = \sqrt{\left\{\frac{1}{T}\int_0^T i^2 dt\right\}}.$$

(9) The effective electromotive force is the square root of the time average of the square of the electromotive force. Thus

$$\text{effective electromotive force} = \sqrt{\left\{\frac{1}{T}\int_0^T e^2 dt\right\}},$$

e being the actual electromotive force at each instant of the time T.

(10) The impedance is the factor by which the effective current must be multiplied to give the effective electromotive force. Thus, in the case of a circuit of resistance R ohms, and self-induction L quadrants in which a simple harmonic electromotive force of frequency $\frac{n}{2\pi}$ is acting, impedance $= \sqrt{R^2 + L^2n^2}$.

(11) In an accumulator the positive pole is that which is connected with the positive pole of the machine when charging, and from which the current passes into the external circuit when discharging.

The Committee are of opinion that they should be reappointed with the addition of the name of Prof. J. Viriamu Jones.

Report on the Present State of our Knowledge in Electrolysis and Electro-chemistry. By Mr. W. N. Shaw.

The following is an abstract:—

I. General electrolytic phenomena.

For a typical specimen we cannot suppose an electrolytic liquid otherwise than a mixture of solutions of chemical compounds, though the amount of all but one constituent of the mixture may be so small as to be regarded merely as impurities which it would not even be possible to detect by ordinary chemical means; thus von Helmholtz said in his Faraday lecture he has detected the polarization corresponding to the decomposition of a quantity of water of the order 1×10^{-11} gramme, and Gore (Proc. Roy. Soc., June 14, 1888) has shown the effect of chlorine upon the E.M.F. of a zinc platinum voltaic couple in distilled water is such that the presence of one part of chlorine in 1000 million parts of water could be detected thereby. Pure water, since Kohlrausch's experiments, is now looked upon as probably not conducting at all. Ratio of conductivity to that of mercury $= 0·71 \times 10^{-10}$ at 21°·5 C., and its sensitiveness to small quantities of impurity approximated to that of the sense of smell, since, when exposed in a room containing tobacco smoke, its conductivity doubled in three hours.

II. Laws and principles generally accepted.

(*a*) The electro-magnetic action of the current passing through an electrolyte is the same as if the electrolyte were replaced by a metallic conductor of the same size and shape and of such resistance that it could be substituted for the electrolyte without altering the current in the rest of the circuit.

(*b*) There are electrolytes in which the conduction of electricity from the electrode to the electrolyte, and again from the electrolyte to the electrode is entirely "convective" in the sense that no electricity can pass into an electrolyte or out of it again without causing a deposit of a certain number of constituent ions at the anode and the opposite ions at the kathode, *i.e.* in certain electrolytes no conduction takes place without chemical decomposition. This holds for a large number of electrolytes, possibly for all. It is not yet substantiated that it is true for all electrolytes, but the evidence is continually accumulating in that direction.

(*c*) The conduction of electric currents through electrolytes follows Ohm's law. Reference is made to Chrystal's experiments on metallic conduction, and Fitzgerald and Trouton's on electrolytic conduction.

One point is the experimental evidence for the deduction from Maxwell's theory of light, that electrolytes being transparent should behave as dielectrics for rapidly alternating electromotive forces. There are two ways of approaching the question—

(1) To find the length of light wave for which electrolytes are opaque.

(2) To find the rapidity of electrical vibration for which the electrolytes cease to conduct.

With reference to (2), Prof. J. J. Thomson says electrolytes still conduct when the rapidity of alternation is 300 millions per second.

(*d*) The only immediate effect of the passage of the current upon the body of a homogeneous electrolyte is to alter the temperature, and the alteration of temperature takes place in accordance with Joule's law.

Full references to the literature of the subject are given in the Report.

Report of the Committee appointed to make a digest of the Observations on Migration of Birds at Lighthouses and Light-vessels which have been carried on during the past nine years by the Migrations Committee of the British Association. Mr. John Cordeaux, Secretary.—The Committee have to report that one of their number, Mr. W. Eagle Clarke, of the Museum of Science and Art at Edinburgh, has, with the approbation of the Committee, undertaken to prepare the digest of the observations; and all the materials for making the same, including 1500 skeleton maps of the British Islands, provided for the purpose, have accordingly been placed in his hands. The labour of reducing the observations, to show in a concise form and on strictly scientific lines the results of the investigation which was carried on from 1879 to 1887 inclusive, will be easily understood to be enormous; and when it is borne in mind that this heavy work can only be carried on after official hours, your Committee feel that no apology is necessary for the non-completion of the digest this year.

Report of the Committee appointed to arrange an Investigation of the Seasonal Variations of Temperature in Lakes, Rivers, and Estuaries in various parts of the United Kingdom in co-operation with the Local Societies represented on the Association. Dr. H. R. Mills, Secretary.—It is inadvisable to attempt at present to summarize the results of observations made, as although more than a year's observations are available on some rivers, it is only a few months since the work has been begun on others. At the end of another year it is expected that sufficient data will be found to justify a comprehensive report on the subject. Several members of the Committee have taken much trouble in collecting observations. Dr. Sorby has been good enough to collect and discuss a great mass of temperature observations which he had made from his yacht *Glimpse*, in the estuaries of the south-east of England during the summer months of five successive years. This will be published separately. Prof. Fitzgerald took charge of the observations in Ireland, where he induced a number of observers to take up the work. Mr. Willis Bund had already inaugurated similar researches on the Severn. Rev. C. J. Steward and Mr. Isaac Roberts rendered important services in their districts. A circular was sent to all the Corresponding Societies in connection with the Association, requesting their co-operation, and favourable replies were received from several, intimating that observations had been commenced. The instructions issued to observers are given as an appendix to the present Report.

Report of the Committee on Solar Radiation.—The actinometer devised by the late Prof. Balfour Stewart, for the continuous measurement of solar radiation which was described in the Report of the Association for 1887, is now ready for preliminary trials, the internal thermometer with a flat bulb of green glass having been made since the date of that Report. The construction of this thermometer occasioned a good deal more trouble than had been anticipated. No attempt has at present been made to render the instrument self-recording, as it would obviously be unwise to incur the outlay which any construction for this purpose would involve, until the result of preliminary trials was such as to encourage a hope that the instrument might really be useful if rendered self-recording.

Report of the Committee appointed for the purpose of taking steps for the Investigation of the Natural History of the Friendly Islands, or other Groups in the Pacific visited by H.M.S. "Egeria." Mr. S. F. Harmer, Secretary.—The Committee have not yet received information which puts them in a position to give any detailed report of the work which is being done in connection with the above subject. The grant has been paid to Mr. J. J. Lister, who reached Tonga on March 19. After devoting two months to the investigation of the natural history of that group, Mr. Lister joined H.M.S. *Egeria*, on her arrival at Tonga, with the intention of visiting Samoa, where, by the latest accounts, he was carrying on his researches.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE thirty-eighth annual meeting of this body was held in the fourth week of August at Toronto, Canada. This is the third time in the history of its existence that the meeting-place selected has been on British territory—the first and second being at Montreal in the years 1857 and 1882.

The arrangements for the entertainment of the visitors were all of that free, open-handed, generous character peculiar to New-World hospitality. A large and representative Local Committee was appointed, and through their instrumentality many facilities for comfort and pleasure were obtained; such, for example, as reduced railway fares, the withdrawal of all Customs duties on instruments, specimens, &c., for use at the meetings, a daily luncheon given gratis at the place of meeting, excursions at reduced rates to Niagara, to the Muskoka Lakes, to the Huronian district, and even across the continent to the Pacific coast. There were also the usual number, or perhaps even more than the usual number, of garden parties, evening entertainments, and small excursions to outlying localities of geological, entomological, or botanical interest. Two public lectures were also given, the subject of the first being the evolution of music, of the second, the geological history of Niagara.

Among those present who took an active part in the proceedings were Prof. James D. Dana; Sir Daniel Wilson, the President of University College, in the Convocation Hall and Lecture Rooms of which the majority of the Sections met; Sir William Dawson, of Montreal; Dr. Charles C. Abbott; Prof. N. H. Winchell, of Minneapolis; Major J. W. Powell, of Washington, the retiring President; T. C. Mendenhall, of Washington, the President for this year; Messrs. Carpmael, Ramsay, Wright, and London, of University College; Profs. Hall and Newberry, who, with Prof. Dana, were the first three Presidents of the Association; Mr. Macoun; Dr. T. Sterry Hunt; Prof. Alexander Winchell, author of "World Life"; Prof. Heilprin, author of "The Geographical and Geological Distribution of Animals," &c.; Messrs. Minot, Morse, Newton, and many others of note. Nor must be omitted the names of Mr. F. W. Putnam, the permanent Secretary; and the following Vice-Presidents of the Association: R. S. Woodward, H. S. Carhart, W. L. Dudley, J. E. Denton, C. A. White, G. L. Goodale, Colonel G. Mallery, and C. S. Hill.

Many sincerely regretted the absence of the learned and genial Professor E. J. Chapman, of University College.

Not much time was wasted at the first meeting in the inevitable speeches and addresses of welcome, and within a couple of hours of the time when the general session was called to order by the venerable Professor Dana, on Wednesday morning, August 28, the various Sections met to organize, preparatory for the delivering in the afternoon of the Vice-Presidential addresses—the Vice-Presidents of the Association being chosen from, and acting as Presidents of, the several Sections.

The majority of these addresses were of a general or historical character. Mr. Carhart, in the Section of Physics, reviewed the theories of electrical action; Mr. Goodale, in the Biological Section, spoke of protoplasm; in the Department of Anthropology, Colonel Mallery dealt with the somewhat curious and little heard of, though not novel, theory of the Hebrew origin of the Indians of North America, discussing the arguments in behalf of that theory, especially the very problematical ground that the plane of civilization and thought of the Indians of to-day was parallel to that of the Israelites of the Old Testament.

Section of Anthropology.

A very large number of the papers read in the Section of Anthropology quite naturally referred to the Indians of the American continent. The following is a list of the more important of these:—

The Huron-Iroquois, by Sir Daniel Wilson.

Evidences of the Successors of Palæolithic Man in the Delaware River Valley, by Dr. Charles C. Abbott.

The Winnipeg Mound Region, by Dr. George Bryce, of the Winnipeg College.

New Linguistic Family in California, by H. Henshaw.

Onodaga Shamanic Masks, by De Cost Smith (Onodaga is a county in the State of New York).

The Phonetic Alphabet of the Winnehago Indians, by Miss Alice C. Fletcher.

The Medawiwin or Grand Medicine Society of the Ojibway, by W. J. Hoffman.

Notes on Aboriginal Fire Making, by Walter Hough.

Aboriginal Mounds of North Dakota, by Henry Montgomery.

The Iroquois White Dog Feast, by Rev. W. M. Beauchamp.

Algonkin Onomatology, by A. F. Chamberlain, of University College, Toronto.

Government of the Six Nations, by O-ji-ja-tek-ha.

Results of Explorations about the Serpent Mound of Adams Co., Ohio, for which a grant was made by the Association, by F. W. Putman.

Aboriginal Monuments of North Dakota, by Henry Montgomery.

Steatite Ornaments from the Susquehanna River, by Atreus Wanner.

Notes on the Eskimo of Cape Prince of Wales, Hudson's Strait, by F. F. Payne, of the Observatory, Toronto.

The following is a brief abstract of Sir Daniel Wilson's interesting paper on the Huron-Iroquois—a branch of a subject in which the writer has for many years conducted important and successful researches:—

The Huron-Iroquois of Eastern Canada.—On the occasion of the first meeting of the American Association for the Advancement of Science in the province of Ontario, it was perhaps a matter of interest to the members of the Anthropological Section to have some special notice of the aborigines of this region to the north of the great lakes. Sir David Wilson accordingly noted that the Indians found in this province on its first occupation by English settlers, as well as those now settled on their reserves in Ontario, are nearly all later intruders than the Anglo-Canadian occupants of the soil. On the Grand River the Six Nation Indians have now been settled for upwards of a century, and have made great progress in civilization. They include the Mohawks, Oneidas, Onondagas, Cayugas, Senecas, and Tuscaroras. But they followed the loyalist British colonists, with whom they had taken part in the War of Independence; and the first of them still preserve the prized heirloom brought with them when they forsook their old native valley of the Mohawk—the silver communion service, inscribed "A.R. 1711. The gift of Her Majesty, Ann, by the Grace of God, of Great Britain, France, and Ireland, and of her plantations in North America, Queen, to Her Indian Chappel of the Mohawks." But though the Six Nation Indians have occupied their reserves on the Grand River for little more than a century, they belong to the great Huron-Iroquois stock, of which Canada is the original home. The speaker accordingly gave a detailed account of the first direct knowledge of the Hurons of the St. Lawrence Valley derived from Jacques Cartier's narrative of his two voyages. He first entered the St. Lawrence in 1535, when he found the palisaded Indian towns of Stadacone and Hoschelaga, on the sites of Quebec and Montreal. We owe to him a vocabulary of their language which proves them to have been Wyandots or Hurons. But when Champlain followed, in 1615, the whole region was a desert. An account was then given of the Huron settlements visited by Champlain on the Georgian Bay, and their extermination by the Iroquois in 1648. Next the traditions of the race were referred to, all in legendary fashion, embodying the myth of their emerging from the heart of a mountain between Quebec and the Great Sea. Their country thus reached, apparently, to the Labrador frontier, contiguous to the Eskimo country. Skulls of the Hurons and Iroquois were produced, including a cast of that of the famous Mohawk chief, Brant; and attention was drawn to the striking contrast which their predominant dolichocephalic type presented to that of the prevalent American type of skull. In this respect the Huron-Iroquois head-form approximates to that of the Eskimo, and the special aim of the paper was to show the reasons for believing in an admixture at some remote date of this American stock with the Eskimo, who have been invariably recognized by ethnologists as a distinct type from the true Indian of the northern continent.

The Rev. Mr. Beauchamp's contribution on the Iroquois white dog feast had some points of interest. Among the Iroquois, the Senecas and Onondagas alone, the writer showed, seemed to have observed the annual white dog feast, and that only within recent times. It combines some features of both the dream and war feasts, of which it is the successor, and is the beginning of the new year. Penitential exercises take up a portion of the time, with games and various performances of the false faces. His sins confessed and forgiven, his appointed offering made and the fire rekindled on his hearth, the Indian was prepared to enter hopefully on a new year, especially if dreams and games had turned out well. The feast has now lost some of its most striking features, and will very soon altogether pass away.

Section of Geology and Geography.

The Section of Geology and Geography also devoted much of its time to topics of American interest. Mr. Charles White, in his address as Vice-President, touched on "The Mesozoic Division of the Geological Record as it is exhibited on this Continent," referring more particularly to the principal subdivisions of the Mesozoic that have been recognized in North America, their inter-delimitation, their division as a whole from the Carboniferous system beneath and the Cænozoic above. He held that the Mesozoic strata of the Atlantic coast region consist of a probable representation of the Upper Trias of Europe, a possible one of the Upper Jura, a probable slight one of the Middle Cretaceous, but with a hiatus between the latter and the Eocene.

Another paper in this Section, dealing in comparisons of Cis- with Trans-Atlantic formations, was that of Prof. H. S. Williams, of Cornell University, Ithaca. He gave an account of his examination of the English Devonian rocks, under the leadership of Messrs. Ussher and Townshend Hall, during the visit of the International Congress of Geologists in 1888. Comparison of the rocks and fossils with those of Eastern North America led to the conclusions (*a*) that the fossils are very closely allied to the species of the New York Devonian, although in the great majority of cases passing under different names; and (*b*) that the rocks, in their appearance, composition, and order, are as different as two distinct systems well can be. The great Devon limestone of South Devonshire and Cornwall furnished the fossils upon which Lonsdale based his conclusion that the fauna was intermediate between the fossils of Murchison's Silurian system and those of the Carboniferous limestone, which led to the establishment of a "Devonian" system. When other European localities had furnished more perfect sections of this system, the fauna of this limestone was recognized as the Middle Devonian fauna, and that of Marwood, Pilton, Sloly, &c., as an Upper Devonian fauna. But neither the order of sequence of the rocks nor the separation of the fossils into well-defined faunas can be satisfactorily determined by study of these Devonian rocks alone. Although they have furnished geological nomenclature with a name for the system, they are far from being typical of the Devonian system, as known to most geologists. Comparison of the faunas of the European Devonian faunas with those of the Appalachian basin leads to the hypothesis that the marine life of the two areas had different histories. There is a continuity in the succession from lowest to highest zones of the system in Europe which we do not find in the American series. It is evident that the American Lower and Middle Devonian faunas are more distinct from the corresponding faunas of Europe than are the "cuboides" and later Devonian faunas of the two areas. To account for these facts it is conjectured that a barrier separated the two districts during the lower and middle stages of the Devonian, and that with the "cuboides" stage an incursion of European species began from the European area westward or north-westward, penetrating the Appalachian basin. The mingling of species was not complete, and was stopped altogether by the elevation which terminated the marine Chemung fauna of the New York area. The author also found evidence for the belief that the early Carboniferous faunas advanced northward in the central and Appalachian basins to take the place of the Hamilton and Chemung faunas, which in large measure ceased.

Mr. Frank Leverett, of the U.S. Geological Survey, read a paper on the glacial phenomena of North-Eastern Illinois and Northern Indiana. The paper opens with an explanation of the methods of study already employed, and other methods to be employed in deciphering the history of the drift. A brief discussion is given of the features and phenomena included under the term moraine as restricted in the paper. Among these features, knobs and basins, swells and says, smooth ridges of till and boulder belts, may be included (though such topography and features are under some conditions non-morainic), but the till plain, "or ground moraine," is not included.

The moraines here discussed are terminal to the *ice* but not to the drift-covered portions of these States. Four evidences of advances in the production of later moraines are cited: (1) buried soils *in situ* between till sheets; (2) changes of direction in flow as shown by striæ; (3) change in form of ice-lobe as indicated by the distribution of the moraine belts and shiftings of the re-entrant and lobate portions; (4) evidence of push or advance in the moraine itself.

The number of distinct moraines varies because of partial coalescence or of local obliteration of portions of certain moraines by later advances. For this reason correlation is difficult. Aside from the difficulty cited there is an increase in the complexity in passing from older to newer moraines. In the older ones the interlobate portions are short, and the moraines can be traced around continuously from one lobe to another through the re-entrant portions. But in newer moraines the terminal loops meet on opposite sides of large interlobate moraines, and correlation is made only after critical study of their connections, over-riding, overwash, &c.

Suggestions are made upon the subject of progressive lobation, but caution is urged against advancing general schemes too early. The study has not been carried far enough to make it possible to draw conclusions of that high order to which future extension of the work will lead.

Before the leading time-intervals in this district can be properly outlined, wider correlations must be made and erosion studies must be carefully prosecuted by competent investigators of erosion phenomena.

Section of Economic Science and Statistics.

Not the least interesting of the papers of this Section was one on "Food Moulds the Race," by Mrs. Nellie S. Kedzie, of the Department of Household Economy and Hygiene in the Kansas State Agricultural College. Mrs. Kedzie traced Irish discontent to the fact that, as she states, whereas "the population of England take on an average 4½lbs. of meat per day," the Irishman eats but 2½ oz. per week. "A hungry man is an angry man," Mrs. Kedzie affirmed, and added, "What wonder that the Irish have grown rebellious, suspicious, and lawless"!

A more serious and important paper in this Section was that of Mr. F. Lester Ward on "The Sociological Position of Protection and Free Trade." The author advocated a protective tariff, and his arguments may be briefly summed up thus:—A protective tariff is a means employed by the State to encourage activities beneficial to that State. The principle is that of inducing certain individuals to put forth energies resulting in benefit to the community at large. Against the argument that public money should not thus be given to private individuals, Mr. Ward urged that the public funds thus spent were analogous to the moneys spent in salaries to Government officials—the end was the same in both cases, viz. the public welfare. A protective tariff tended to make the State self-sustaining. The statesman is not a humanitarian; his duty is the weal of his own country. He is justified, therefore, in advocating measures of self-defence. But as with individuals, so with States: those acts which are performed for the object of self-defence conduce to the welfare of the collective whole. There is no such thing as free competition. The term itself implies friction. It requires intelligent interference to preserve competition free. Competition left to itself promotes monopolies. The protective tariff prohibits the unnecessary transportation of commodities. This results in economy.

But the paper that attracted the largest amount of attention in this Section was that of Mr. B. E. Fernow, chief of the Forestry Division of the Department of Agriculture of the United States. A graduate of a Forestry Academy of his own country, Germany, where, as he himself said, the preservation of forests is traditional, Mr. Fernow is astonished at the careless—in many cases, indeed, deliberate—wastefulness with which the New World utilizes its treasures of timber, and he looks to the Government to remedy the evil. "As far as the forest yields material for the arts," he said, "it is an object of private industry; but when, by its position on a watershed, the forest becomes an influential factor in the water conditions of the plain, it may still serve the purposes of gain and wealth, which are the objects of private industry, but its indirect significance for society at large exceeds the private interest, and this class of resources, being in the direction of a social gain or gain for a larger number, must become an object of public economy by the State or community."

The following passage from Mr. Fernow's paper is worthy of quotation, showing as it does his perspicacious views on this difficult problem of forest conservation:—

"Whatever tends to stimulate private activity is to be promoted. Whatever retards development of intensive methods is to be removed by Government. Industrial education, cultural surveys, organization of national irrigation systems, fish commissions, bureaus of information, experimental stations and other aids to private enterprise will constitute the chief methods of expressing State interest with regard to these resources. The three great sources upon which mankind is most dependent, which demand first the attention of the State, are the soil, as food producer, the water, and climatic conditions. A rational management of the water capital of the world in connection with the agricultural use of the soil will become the economic problem of the highest importance, as the necessity for increased food production calls for intensive methods. In the United States the action of the Government on economic and cultural questions is apt to be fitful and the result of personal influence rather than a logical analysis of conditions and principles. While our Government is ready to go to war in order to protect its fisheries, it has never even known the value as food supply of the game which has been killed. Whole races of animals have been extirpated before there were population enough to require the meat. While with one hand we pay exorbitant prices in land and wasted energy to get the plains re-forested, and that with poor success, with the other hand we offer a premium for forest destruction in mountains by leaving them without proper administration. And now we propose to establish irrigation systems, neglecting to provide first for those conditions which assure a regulated water supply—namely, by forest preservation."

This paper led to the adoption by the Association of three resolutions: one, that Congress be memorialized on behalf of a proper administration of the forests of the western mountain ranges; a second, that legislative enactments were necessary for the development of natural resources; and a third, appointing a committee to urge the importance of these matters on the President and Congress of the United States and on the Premier and Parliament of Canada.

Section of Chemistry.

The Vice-Presidential address in this Section was read by Prof. William L. Dudley, of Vanderbilt University, who gave a *résumé* of the more important researches on the nature of amalgams, to which was appended a very complete index to the literature on the subject. Prof. Dudley confined himself almost wholly to the historic aspect of his theme, taking occasion only to remark that the results of previous experiments seem to prove that amalgams are chemical compounds more or less unstable.

Mr. Charles Munro spoke on the explosiveness of the celluloids. He gave the results of experiments for testing their stability, flashing-point, &c., and maintained that the opaque varieties were insensitive to detonation at ordinary temperatures, but that the translucent readily exploded.

Mr. John W. Langley, of Pittsburg, read a paper on "International Standards for the Analysis of Iron and Steel." He stated that a system of international standards had been arranged for between England, France, Germany, Sweden, and the United States. He gave a description of the system, and asked the Section to name one chemist to act with six others to conduct the analysis on behalf of the American Committee on the International Standards, and to co-operate regarding the same with European analysts. The meeting appointed Mr. Thomas M. Brown, of Boston, with Prof. F. A. Gooch, of Yale College, New Haven, Conn., as alternative.

Section of Mathematics and Astronomy.

In the Section of Mathematics a paper—which resulted in an important resolution being adopted by the Association at large—was read on the Peruvian arc. The two meridional arcs, the one in Peru and the other in Lapland, measured a century and a half ago, were examined by Mr. E. D. Preston, of the United States Coast and Geodetic Survey, with reference to the degree of accuracy attained, and a comparison was made between the uncertainties of these measures and those resulting from work with modern instruments, and following more recent methods. It was shown that the probable errors were much larger than would be indicated by the agreement of the published results, and that therefore the concordance of this arc with those in other parts of the world is no proof of its accuracy. By far the most significant errors came from the astronomical observations, and the unavoidable uncertainties here, either from the imperfection of the instruments, or the attraction of the high mountains, were shown to affect perceptibly the present value of the earth's axis.

The resolution touching this matter, which was unanimously adopted at a general session of the Association, reads as follows:—

"Whereas the history of geodesy includes no more important page than that relating to the measurement in 1739 of the so-called Peruvian arc, which work was conducted by the French Government with the co-operation of Spanish officers, and in magnitude of plan and difficulty of a most serious character it was in its time unexcelled; whereas recent improvements in all the processes incidental to such an undertaking have been so very great, rendering possible a vastly more accurate execution of the work; whereas it is and has been for several years a matter of deep regret that the one great contribution which the American continent has made to the solution of the problem of the figure of the earth should fall so short of what it should and might: be it therefore resolved by the American Association for the Advancement of Science, that the Congress of the Three Americas about to assemble in Washington is earnestly requested to consider the desirability of undertaking the measurement of this Peruvian arc, to be accomplished by a union of the Republics represented. This result is not likely to be reached except through international effort, and this recommendation by the Congress would be a fitting and proper act of this first conference of representatives of the New World."

Section of Physics.

The President of the Association, Mr. T. C. Mendenhall, read before the members of this Section a short paper on globular lightning. He adduced no new theory as to its source or character, but submitted an interesting account of several authentic records of its occurrence, many of them abstracted from the reports sent in to the United States Hydrographic Office. He showed that there was abundant trustworthy proof that atmospheric electricity took on the form of globular lightning, but conceded that the evidence was in details discordant. He hoped that some day opportunity might be given to obtain a photograph of the phenomenon.

Mr. Thomas Gray read a paper on the relative values of the magnetic and the electrodynamic methods of measuring electric currents in absolute measures.

In the subsequent discussion on the paper, Prof. Nichols, of Cornell University, stated that he had compared the constants of one of Sir William Thomson's balances as certified by him, with the constants as determined by the large standard galvanometer in Cornell University, and found them to agree perfectly through the entire range—a result with which he was greatly pleased.

Prof. H. S. Carhart, of the University of Michigan, read two papers before this Section, one on magnetic leakage in dynamos, the other on an improved standard cell with low temperature coefficient. The following abstracts of these papers will show their gist and purport:—

The first paper gives an account of some experiments to determine the magnetic leakage of two dynamos of the Mather and Edison type respectively; the former was a small machine of 500 watts capacity, built by a student in the laboratory, the latter an Edison of 5000 watts capacity.

In the small machine the leakage was due to some projecting machine steel studs which carried the armature yokes. The number of magnetic lines cut by the armature when the machine was coupled as a self-exciting shunt dynamo was determined, and then the steel studs were replaced by brass and the determinations were repeated. The result was 190,000 and 252,000 lines of force respectively, or a gain due to removing the steel studs of 32·6 per cent. This was partly due, however, to increase in the field when the leakage was stopped. Hence the machine was independently excited by a storage battery, and the number of lines determined in the two cases as before. The result was 164,600 and 184,100 lines cut by the armature with and without steel studs, a gain of 11·2 per cent. This measured the true leakage due to the assigned cause.

The leakage in the Edison machine was due to the iron bed-plate. A plank base was made, and the number of magnetic lines cut by the armature was determined first with the iron base and then with the plank, the machine being self-exciting and running at the same speed in the two cases. The number of lines was 1,510,000 and 1,605,000, a gain of 6·25 per cent. due to removal of the cause of leakage.

In his second paper, on an improved Clark standard cell with low temperature coefficient, Prof. H. S. Carhart said:—"The objections to the Clark cell, as described by Lord Rayleigh, are high and variable temperature coefficient, objectionable mechanical construction, and serious local chemical action. These I have, at least in large measure, overcome. The cell which I now make is so constructed that the mercury cannot reach the zinc during transportation. The temperature coefficient is represented by the equation

$$E^1 - E[1 - \cdot000387(t - 15) + \cdot0000005(t - 15)^2].$$

Per degree the coefficient is

$$- \cdot000386 + \cdot000001(t - 15).$$

At 0° C. this coefficient becomes − ·000401; at 25°, − ·000376; and at the highest temperature observed, 52°·7, it is − ·000348. It will be observed that this coefficient diminishes with rise of temperature, while that of Lord Rayleigh's cells increases. In cells of the old form local action is due to zinc replacing mercury when in contact with the solid mercury salt. The zinc is thus amalgamated, and the amalgam creeps up. This I prevent by keeping the zinc out of contact with the mercury salt. The same device has the effect of raising the E.M.F. about 0·4 per cent. The polarization of these cells amounts to only one ten-thousandth part in five minutes with an external resistance of 10,000 ohms. It recovers in a few minutes. The different cells show great uniformity of E.M.F. All comparisons are made by Lord Rayleigh's method slightly modified. A charge or difference of E.M.F. of one ten-thousandth part is very readily detected."

In this Section Messrs. W. A. Rogers and R. T. Woodward, in a paper on mercurial thermometers, held the following theses:—(1) The movements of a mercurial column are in all cases by pulsation; (2) these pulsations have a regular recurrence; (3) the period of recurrence is constant in the same thermometer; (4) every pulsation has the same harmonic relation; (5) the amplitude of the curve which represents the harmonic is inconstant; (6) as the period is constant and the time required for the completion of the cycle variable, it follows that the danger of error in random readings of the thermometer is greater for slow than for rapid variations of temperature.

Section of Biology.

In the Biological Section, Mr. A. J. Cook read an interesting paper on the alimentary apparatus of the bee, in which he embodied the results of a long series of personally conducted experiments. He differed, he said, widely in many particulars from the author of the article on the anatomy of the bee in the "Encyclopædia Britannica," notably as regards the conformation of the tongue. This organ, Mr. Cook strongly maintained, was a hollow cylinder furnished on the under side with a slit throughout its entire length. He explained that suction could be performed in three ways: (1) through the terminal aperture of the internal tube, when the nectar could be reached only by the end of the tongue; (2) through the slit opening into this tube, when the fluid to be sucked in was shallow and placed on a flat surface; (3) by the aid of the labial *palpæ* when the fluid was abundant. The author also expressed his incredulity as to the possibility of a trustworthy analysis of honey, arguing that in many cases more nectar was taken into the honey-stomach by the bee than the glands had time or secretion sufficient to digest. Especially, he thought, did this happen when the linden was in bloom, when a single hive of bees would sometimes store up 15 pounds of honey in the day. The queen bees and the drones, he held, were fed with digested food only, and to this fact he traced the extraordinary fecundity of the queen bee.

Prof. Burrill read a paper on fermentation of ensilage. He stated that all fermentation of organic matter is now universally admitted to be due to the action of micro-organisms, and he described the phenomena presented in recently stored green fodder, used for cattle food. This material is now placed in bins of large size, where it soon becomes very hot, reaching a temperature of 60° C. (140° F.). This temperature was sufficiently high to kill or at least prevent the growth of nearly all animal and vegetable species, 50° C. being the upper limit. Upon the proper examination of this hot material one soon finds that a single species of Bacteria (*Bacillus butyricum*) is associated with the fermentation and subsequent rise in temperature. Further tests prove that it is the cause of these changes. Secondary changes are very liable to occur as the heat decreases, and lactic and acetic acid, the latter often in large amounts, are produced. Possibly alcohol is sometimes, but never as a first product of the hot material.

On the whole, this the thirty-eighth annual meeting of the American Association for the Advancement of Science may be considered to have been a successful one. Close upon two hundred papers were actually read in the various Sections, some of these of course not reflecting that "dry light" which is supposed to beat upon all scientific investigation, yet the majority of them evincing real and enthusiastic work on proper lines. One thing, however, might have been noticeable to an English ear, many of the writers seemed to possess a greater mastery over abstruseness of subject than over elegance of diction.

Many eminent men, some famous in both hemispheres, were present. The total number of persons in attendance on the meetings, and actually belonging to the Association, either as Fellows, Members, or Associates, was between four and five hundred.

Financially, the Association is declared to be in a better position to-day than ever it has been before. The annual income is at present about $6000. It has also the sum of $4500 invested at 5 per cent., the interest of which is devoted to the furtherance of original research. For the ensuing year this sum has been apportioned thus: $150 to Prof. Moseley to continue his researches on the velocity of light in the magnetic field; and $50 to Prof. Attwater for the purpose of investigating the heats of combustion of certain mineral and vegetable compounds.

Indianapolis and the third Wednesday in August were chosen as the place and time of meeting for 1890. Mr. G. L. Goodale, of Cambridge, Massachusetts, was elected President for the coming year.

The meeting was closed by a public gathering, at which many complimentary speeches were made both by hosts and guests.

ARNOLD HAULTAIN.

THE IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held last week in Paris under the presidency of Sir James Kitson. The meeting was held in the rooms of the Société d'Encouragement, and was addressed, in the first instance, by M. Eiffel, President of the Société des Ingénieurs Civils, and by M. H. de la Goupillière, President of the Société d'Encouragement. The President of the Institute, after thanking M. Eiffel and M. de la Goupillière for their kind hospitality, announced that the Council had awarded the Bessemer Medal to M. Henri Schneider, of Creusot, for his services to the iron and steel trade of France, to whom it was presented on Friday by Sir Lowthian Bell. Sir James Kitson made a brief address, referring to their last visit to Paris in 1878, under the distinguished presidency of the late Sir William Siemens, to the increase in the roll register of the Institute which had taken place since that date. He drew attention to the improvements which had taken place during the last decade in the metallurgy of steel and iron; the commercial development of the Siemens-Martin and Thomas-Gilchrist steel processes; the increased development in the manufacture of steel owing to the extension which had taken place in its applications. The Eiffel Tower was an elegant example of the scientific power and imaginative genius of French engineering, whilst the French chemical study of the processes of metallurgy had rendered great service, not only to their own industry, but to that of the world at large. The names of many eminent French metallurgists were mentioned, and the work they had done was briefly referred to.

The business of the meeting was then proceeded with, viz. the reading and discussion of the various papers which are referred to below.

Prof. S. Jordan's paper, "Notes on Iron and Steel Manufacture in France in 1887, and as illustrated by the French exhibits at Paris," the first paper read, was of a statistical character, and compared the present production of these metals with what it was ten years ago.

The Channel Bridge.—This was a paper by Messrs. Schneider and Co., of Creusot, and M. H. Hersent, Past-President of the Société des Ingénieurs Civils, descriptive of a bridge for connecting England with the Continent. The paper consists of three parts, an introductory notice, a general description of the bridge, and of the superstructure, being preliminary projects of M. Hersent and Messrs. Schneider respectively. From the introductory notice it would appear that projects have been submitted by Messrs. Fowler and Baker, but these are not published in the paper.

It is proposed that the bridge should span the Channel at about its narrowest portion—namely, between Folkestone and Cape Griznez, a distance of 25 miles, by which means also the sand-banks of Varne and Colbart can be taken advantage of, thereby diminishing the height of the piers necessary to be erected. These banks are in mid-Channel, about 3¾ miles apart, and are separated by a depression of between 80 and 90 feet deep; this is also about the depth between the bank and the British coast, whilst on the French side, between the Colbart Bank and the Cran-aux-Œufs, the bottom sinks somewhat abruptly down to 132 feet, attaining 180 feet about midway across, when it gradually rises again. In these parts the chief difficulties would be encountered in laying the foundations. As the result of frequent experiments, it is found that the blue and white chalk which forms the Channel bottom is capable of supporting a load of from 140 to 170 pounds to the square inch, and the surface of the bases of the piers has been so calculated that the foundations should not have a greater load on them than the smaller of these amounts. This would imply that no factor of safety has been allowed, which is hardly likely to be the case, as in masonry structures with a live load a factor of safety of 8 is generally recommended; on the other hand, the ordinary kinds of chalk are capable of resisting a crushing pressure of 330 pounds per square inch. The masonry piers are 190 feet in length at the base, and 140 feet above, the width depending on the columns which they have to support. The distance between the piers is fixed at 1650 and 990 feet, 1155 and 660 feet, and 825 and 330 feet, the largest spans corresponding to the greatest depths, and the smaller ones to smaller depths and the parts near the shore. Each supporting pier will consist of a block of masonry of best material, set with Portland cement, and laid on the sea bottom; the masonry will be built inside metal caissons similar to those used for ordinary bridge piers, and forced by compressed air down to the solid ground. Their surface above high-water level will form the foundation for the metal columns, which are cylindrical in shape, and vary in height between 132 and 140 feet, and on them are placed the main girders of the bridge. These girders are 200 feet above low-, and 178 feet above high-water level. This height is amply sufficient for the passage of the largest ships. The system of girders proposed to be employed is simple, unlatticed, trussed, so as to insure the proper distribution of all the stresses. After consideration it has been found advisable, instead of forming the 990 and 1650 feet spans of girders extending over the whole length of 990 feet, and extending on either side in the form of cantilevers of 825 feet, so that the junction of the two cantilevers should constitute a span of 1650 feet in all, not completely to cover the spans by means of cantilevers, but to connect these by an ordinary independent span, a saving of 17 per cent. being thus realized in each overhanging portion of the cantilever. In this manner the 1650-feet span comprises two cantilevers of 619 feet each, and an independent span of 412 feet. The metal flooring on the central span and cantilever is formed of two girders resting upon two piers 990 feet apart, and lengthened on either side to the extent of 619 feet. These girders are 36 feet high at the ends of the overhanging portions, and 214 feet high almost throughout the span of 990 feet. Each girder consists of two chords connected by bracings forming isosceles triangles. The lower ribs of the two girders have a distance of 82 feet between their axes in the central span of 990 feet, and an interval of 33 feet at the ends. The level of the permanent way is 237 feet above low water; a double set of rails is proposed, and the width of flooring proper will be 26 feet.

The paper further gives a detailed description of the foundation work, comprising the situation and dimensions of the piers, the construction, conveyance, and fitting into position of the supporting columns, and the materials and machinery required for the completion of the work; also the construction, transport, and putting into position of the metal spans, with estimates of weight, and calculations of the resistances throughout the structure. The metal required for this bridge would amount to a million tons, of which about three-quarters would be steel; the cost is estimated at £35,000,000, and the period requisite to complete the work ten years. This interesting pamphlet of nearly 100 pages will be referred to on account of the careful manner in which the subject has been brought forward, even should the building of the bridge not take place, on account either of political objections or constructive difficulties. As stated in the paper itself, each pier comprises a small lighthouse, and as about 150 of these small lighthouses will have to be erected, an injury to any one of which would close the bridge for a lengthy period, one thinks of the Eddystone Lighthouse, built by Smeaton 100 years ago, which has had to be replaced, not on account of any fault in its design or construction, but because the sea had made inroads on its foundation of rock.

On Gaseous Fuel, by Sir Lowthian Bell. The author assumes a certain quality of coal, and then compares the work that can be performed with it according as it is used in the solid state or in the condition of producer gas or in that of water gas. Producer gas is that supplied to the Siemens regenerative gas furnace; the specimen of coal used for comparison is assumed to consist of 70 per cent. fixed carbon, 16 coal gas, and 14 ash, oxygen and nitrogen, and the producer gas obtained from it of 16 parts of coal gas, 163·3 of carbonic oxide, and 222 of nitrogen, the producer gas being supplied cold at the foot of the regenerators; the calorific value of the coal is 7200 calories. 100 parts of this coal are equal to 720,000 calories, and by the combustion of the producer gas 551,920 calories are produced, showing a loss of 168,080, equal to 23·3 per cent. The method of manufacture of water gas is next explained. The fuel recommended to be employed is coke, which is placed in a cylinder of iron lined with fire-brick; the coke is rendered incandescent by an air blast. When in this state the blast is stopped, and a jet of steam passed through it. The steam is decomposed; its oxygen burns the carbon into carbonic oxide, setting free the hydrogen, the mixture constituting so-called water gas, comprising equal volumes of carbonic oxide and hydrogen. The change in producing water gas is expressed chemically by $H_2O + C = H_2 + CO$, and the heat required to tear hydrogen away from its associated oxygen is not less than that evolved when the two gases unite, or 2 × 34,200 = 68,400 calories. The weight of the combining equivalent of carbon required to effect the change is twelve times that of the two units of hydrogen, and the heat generated by this quantity of carbon being burnt to carbonic oxide is 12 × 2400 = 28,800, so that something over 14½ units weight of carbon will be required to generate a unit weight of hydrogen. But as only 6 units of carbon are being burnt per unit of hydrogen, the incandescent carbon is soon cooled down below the temperature of decomposition. When this point is arrived at, the steam is shut off, and the blast is again turned on. Using the data given in the water gas publications, water gas produces per 100 parts of carbon 682,520 calories out of a possible total of 800,000, there being a loss of 14·68 per cent.; as the coke used is produced from coal, the actual loss rises to 37 per cent. The author sums up as follows:—

(1) Coal as burnt in an ordinary furnace—

		Calories.
100 parts, yielding 7200 calories per unit	=	720,000
Chimney gases, estimated after making the necessary allowance for oxygen in the coals, 1129 units × 427° C. × ·24 specific heat	=	115,700

the loss in this case by chimney gases being equal to 16·07 per cent.

(2) Producer gas from same coal, as used in the Siemens furnaces, without the addition of steam—

		Calories.
70 of carbon or 133·33 of CO × 2400	=	391,992
16 of coal gas × 10,000	=	160,000
Sensible heat transmitted to furnace		62,411
		614,403
Heat in chimney gases, 1129 × 377° C. × ·24 specific heat	=	102,151

Loss of chimney equal to 16·61 per cent.

(3) Water gas and its accompanying producer gas—

		Calories.
Water gas, 17°·5 C. = 40·83 CO × 2400	=	97,992
Hydrogen from steam, 2·926 × 29,400	=	86,024
		184,016
Producer gas, 52°·5 C. = 122·5 CO × 2400... ...	=	294,000
Coal gas, 16 × 10,000	=	160,000
Sum of heating-power of water gas and producer gas...		638,016

Heat in a chimney gas assumed at same temperature as ordinary producer gas—

779·7 × 377° × ·24 sp. heat = 70,547 calories = 11·05 per cent.

These figures intimate that each 100 units of the three kinds of fuel burnt there is afforded by: coal, 83·93; producer gas, 71·14; water gas and its producer gas, 78·80.

To these figures of Sir Lowthian Bell the supporters of gaseous fuel will object that, if with the use of gaseous fuel there are 1129 units of waste gases passing up the chimney, with solid fuel there must be considerably more; whilst the employers of the regenerative gas-furnace, whilst accepting 377° C. as the temperature of their chimneys, will not allow the same for water gas, where regenerators are not used.

Another interesting paper presented to the meeting was one by Mr. W. C. Fish, on the Thomson electric welding process. The *rationale* of the process may be thus shortly described. If an inclosed circuit of inappreciable resistance be completed by the insertion and abutment of short lengths of the pieces to be welded, the passage of an electric current through the circuit will produce a transformation of electric into heat energy, and the production of this heat will take place almost entirely at the point of abutment of the metal pieces where the cross-section of the conductor is virtually of least area, and the resistance is proportionately great. If the current is of sufficient strength, a welding heat is produced at the point of abutment, and, with the aid of suitable pressure forcing together the heated extremities of the pieces, a weld is made. Various applications are given in the paper, the employment of an alternating current dynamo and a transformer being found the most effective method of working.

Mr. Alexander Siemens, in the discussion of this paper, said he was able to confirm the general results given, for in making one of the Atlantic cables twelve years ago, it was found that welding could be done more quickly by electricity than by ordinary means. An electrical machine was placed alongside of the cable machine, and they made all the joints for the sheathing of the wire by electricity. They would find that the subject had been mentioned by Sir William Siemens in his address to the Mechanical Section of the British Association at Newcastle in 1877.

Papers were also presented to the meeting on the Robert-Bessemer steel process, by Mr. F. L. Garrison, of Philadelphia; on alloys of iron and silicon, by Mr. R. A. Hadfield, of Sheffield, both being papers of a technical character. A new form of Siemens furnace, arranged to recover waste gases as well as waste heat, was described by Mr. John Head, and M. P. Pouff, of Nevers. In this furnace, instead of two air and two gas regenerators being employed, only a pair of air regenerators are used, the gas being supplied hot to the furnace. Instead of the whole of the products of combustion being passed through the regenerators, a portion is directed through a regenerator to the chimney, and the remainder through a converter producer, there to be reconverted into combustible gases, and to do the work of distilling hydrocarbons from the coal; in fact, the gas producer or converter in this furnace absorbs or utilizes the heat formerly deposited in the gas regenerators, and in doing this transforms spent gases into combustible gases. It had to be ascertained whether the products of combustion from the heating chamber would contain a sufficient amount of heat to insure their conversion into combustible gases; this has been found to be the case in practice with furnaces working for the past six months. Assuming that the producer contains only coke in the incandescent state, this coke if fed with oxygen will produce carbonic acid in the lower, and will be converted into carbonic oxide in the upper zone of the producer; if fed with hot carbonic acid instead of oxygen, one-half the fuel, comprising the lower zone, may be dispensed with, and an economy in weight of fuel to the same extent realized. In actual practice finished rolled iron has been heated in this furnace with a consumption of fuel as low as 2 cwt. per ton of iron.

SCIENTIFIC SERIALS.

American Journal of Science, September.—From experiments here described, Messrs. A. A. Michelson and E. W. Morley infer the possibility of establishing a material standard a metre long, whose length in light-waves is known to within one part in one million, and perhaps one in ten millions.—Mr. H. Crew has measured spectroscopically the solar rotation for a zone some 60° wider than any before observed, getting the equatorial value 26·23 days, and finding no certain variation of period with latitude by this method. A comparison of the results from various methods appears to suggest a decrease of angular velocity outwards.—Stretching suddenly soft annealed wires by descent of weights through a trap door, and measuring thermo-electrically the heat evolved, Mr. C. Barus finds that as much as one-half the work done in stretching up to the limit of rupture may be stored up permanently. The work thermally dissipated varies (*e.g.* 75 per cent. for copper, 60 for brass, and 50 for iron); and with a given metal, there is large potentializing in the first stages of strain, and large dissipation in the final stages.—Mr. J. Trowbridge shows reason for thinking that short waves of electrical energy are not absorbed by an approximately perfect dielectric.—A determination of the value of the B.A. unit of resistance in absolute measure by the method of Lorenz, by Messrs. Duncan, Wilkes, and Hutchinson, yields the value 0·9863 ohms.—The Carboniferous Echinodermata of the Mississippi basin are studied by Mr. C. R. Keyes. Crinoidea greatly predominated in the first part, and Blastoidea in the later part, of the period. Abrupt differentiation and extinction of genera towards the end of the Keokuk formation, point to decided changes in the environment.—Mr. M. Carey Lea continues his interesting account of the properties of allotropic silver. No other metal seems capable of such a variety of appearances. *Inter alia*, he notes the remarkable beauty of colouring in rings produced by a small crystal of iodine placed on paper that has been coated with allotropic silver in its moist and plastic state.—There are also papers on the "Grand Gulf" formation of the United States (Mr. L. C. Johnson); paragenesis of allanite and epidote as rock-forming minerals (Mr. W. H. Hobbs); a fossil spider (Mr. C. E. Beecher), &c.

Revue d'Anthropologie, troisième série, tome iv., quatrième fasc. (Paris, 1889).—Scientific anthropometry and artistic proportions, by Colonel Duhousset. In treating of the origin of anthropometric canons of proportion, the writer considers that while there is no doubt of the influence exerted by the Egyptians on Hellenic art, the beauty of their own people must early have led Greek artists to adopt, as typical models for the representations of their divinities, the most highly developed specimens of the human form, as it was manifested in their immediate neighbourhood. It would appear that the most ancient canon of beauty recognized by the Greeks was derived from Polycletus (452-412 B.C.), whose celebrated statue, "Doryphorus," the spear-bearer, was long known as "canon" from its perfect embodiment of the ideal of the male figure. A century later this type gave place to the more idealized representation of Lysippus, who in his statues of the gods raised the height of his figures from the ordinary proportion of 7½ to 8 heads. Under Vitruvius the proportions of Lysippus received greater precision, and became the type that has essentially served through later ages as the true canon for the perfect human form. The purpose of the writer is to compare this artistic type with a scientific canon, for the establishment of which our recent progress in anthropology now for the first time supplies the necessary materials.—In a subsequent article, M. Topinard, following up the relations between these two canons of proportion, treats of the differences between the methods followed by the artist and the anthropologist. He considers that the establishment of a scientific canon demands a careful study of the skeleton and the body immediately after death, as well as of the living subject, and his observations, elucidated by numerous tables, will be found of great value to the artist. He suggests, *e.g.*, that the decimal system of measurement should be used in determining the proportions of the several parts of the body to the whole body, while racial and sexual differences should be taken into account before the height of the figure is determined. This preliminary step is of importance, for while all races have a general similarity in the proportion of the height of the head to the whole body, the yellow races have comparatively "high" heads. Women, moreover, in all races, other things being equal, have higher heads than men. M. Topinard concludes that there is no fixed relation between variations in the height of the head and those of other parts of the body, and that, consequently, the artistic method of taking the head as a standard for the relative proportions of the rest of the body is erroneous. Hence there is no absolute type of beauty, the canons of proportion varying with sex, age, race, and individuals.—On vestiges of pagan practices among the Provençals of our own days, by Dr. B. Férand. The Provençals, who from their origin were powerfully influenced by the Greeks and Romans, still retain in their modes of worship, and their social and domestic habits, numerous traces of paganism. Curious instances of this are supplied by the practice of libations, still followed by the peasants of Provence, who, after having concluded some unusual transaction, or an agreement of importance, commemorate the event by pledging those present, after which they invariably extend the right arm and turn their glass down, so as to let the last drop fall to the ground. Similarly, at the festival of Christmas, which is locally known as "Leis Festos de Caleno" (the Calends), a solemn repast is partaken of, known as "Lou gros Soupar," at which the eldest and the youngest member of the assembled family perform, amid a profound silence, the ceremony known as the "benediction of the fire." This act is performed by pouring wine three times upon the burning log, which must be of oak or olive wood. This is accompanied by the singing of some verses, in which the excellence of fire is praised, and God is thanked for having given man beneficent heat. These verses vary in different localities, but everywhere the ceremony of the silent libations precedes the supper of which the combined household partake.—On lacustrine and other pile-structures in Northern Italy, by M. P. Castelfranco. The writer gives an interesting summary of the various works which have appeared in Italy in recent years, regarding the different forms of pile-structures discovered in the Parmese and neighbouring lowlands. In Italy such explorations date back only to 1861, when MM. Pigorini and Strobel discovered extensive remains of prehistoric pile-dwellings at Castione. Since then other explorers, more especially Dr. Chierici, have followed up these researches in the province of Reggio, where the latter discovered traces of a *chaussée* raised above the level of the ground on closely adjusted piles. The remains of some of the pile-dwellings showed, moreover, that there had been in course of time as many as three distinct structures raised the one upon the substructures of the others. The animal remains and the flint implements found in the *débris* belonged to the Bronze Age. M. Castelfranco's summary is worthy of the careful attention of our most distinguished palæontologists, while the important facts which he adduces appear to warrant the interesting conclusion that in these palustrine habitations of Northern Italy we have the most ancient Italian stations of the tribes, from whom descended those prehistoric peoples whose occupation of the country is attested by the celebrated cemeteries at Villanova, Bologna, &c., which belong to the earliest period of the Iron Age. M. Pigorini believes that the civilization of the palustrine and land-pile dwellings—the *terremare* of Northern Italy—is identical with that of prehistoric Hungary, which gradually penetrated to Central Europe by the Danube and its great affluents, the Drave and the Save, but never advanced to the western districts of France, or to Britain, where there is no trace of any but lacustrine pile habitations.

SOCIETIES AND ACADEMIES.

LONDON.

Entomological Society, September 4.—Captain H. J. Elwes, Vice-President, in the chair.—Prof. C. H. Fernald and Mr. C. J. Fryer were elected Fellows; and Prof. C. V. Riley and Dr. A. S. Packard were admitted into the Society.—Mr. G. T. Baker exhibited two remarkably dark specimens of *Acronycta ligustri* taken near Llangollen.—Dr. P. B. Mason exhibited and remarked on a collection of Lepidoptera which he had recently made in Iceland. The following species, amongst others, were represented, viz.:—*Crymodes exulis*, *Triphæna pronuba*, *Noctua conflua*, *Plusia gamma*, *Larentia cæsiata*, *Eupithecia scoriata*, *Melanippe sociata*, *Coremia munitata*, *Phycis fusca*, and *Crambus pascuellus*.—The Rev. Dr. Walker also exhibited a number of Lepidoptera, Diptera, and Hymenoptera, recently collected by himself in Iceland.—Mr. W. White exhibited, on behalf of Mr. G. C. Griffiths, a specimen of *Nephronia hippia*, Fab., var. *gæa*, Feld., which he believed to be hermaphrodite. He also exhibited, for comparison, a female of the same species. A discussion on hermaphroditism ensued, in which Mr. Distant, Captain Elwes, Mr. McLachlan, and Mr. Baker took part.—Dr. Sharp exhibited specimens of *Cychramus luteus* and *fungicola*, Auct., and stated that they are the sexes of one species, *C. luteus* being the male, *C. fungicola* the female. In working through the Central American *Cychramini*, he had found that in some genera the males differed greatly from the females in size and sculpture; but this was not a constant character, for in some species, while certain males scarcely differed from the females in these respects, others were so different that they would scarcely be recognized as belonging to the same species.—Mr. E. A. Butler exhibited specimens of *Platymetopius undatus*, from Ewhurst, Surrey. He remarked that the species was recorded as having been once previously taken near Plymouth by the late Mr. J. Scott.—Mr. G. T. Baker read a paper entitled "On the distribution of the Charlonia group of the genus *Anthocharis*." Mr. Baker stated that the species of this small division of the genus Anthocharis formed a very natural and closely allied group, presenting many points of interest, both in their relationship to each other, and in their geographical distribution, which extended from the Canaries on the west to the valley of the Indus on the east. The author's theories as to the causes of the present distribution of the group, which were based on geological data, were discussed by Captain Elwes, Mr. McLachlan, Mr. Distant, and Mr. Stainton.—The Chairman read a paper entitled "On the genus *Argynnis*," which gave rise to a discussion in which Mr. Distant, Mr. Jenner-Weir, and Prof. Riley took part.

SYDNEY.

Royal Society of New South Wales, August 7.—Sir Alfred Roberts, Vice-President, in the chair.—The Chairman announced that the Council had awarded the Society's bronze medal and a money prize of £25 to the Rev. John Mathew, Coburg, Victoria, for his paper upon the aborigines of Australia: also that the Clarke Memorial Lectures would be delivered to the members of the Society by Mr. C. S. Wilkinson, Government Geologist, as follows: (1) on the geological researches of the late Rev. W. B. Clarke, F.R.S., S. Stutchbury, and other early Australian geologists, November 13; (2) on the geology and ancient life-history of Australia, November 20; (3) on the economic geology of Australia, November 27.—The following papers were read:—On the source of the underground water in the western districts, by H. C. Russell, F.R.S.; on the eruptive rocks of New Zealand, by Capt. F. W. Hutton; on the application of prismatic lenses for making normal-sight magnifying spectacles, by Mr. P. J. Edmunds; flying-machine memoranda, by Lawrence Hargrave.

PARIS.

Academy of Sciences, September 23.—M. Des Cloizeaux, President, in the chair.—International Congress of Chronometry; International Congress of Applied Mechanics, by Mr. Phillips. The former, at his instance, expressed the desirability of thorough experiments, at Government expense, to determine how compensation is affected by the nature of metals and alloys used for springs and balance wheels, and the various types of the latter. The other Congress expressed a similar wish for the formation of testing laboratories for materials and machines, and for an International Commission to fix units and uniformize methods; it also proposed definitions of the terms used in mechanics. M. Mascart called attention to the fact, that, while the proposed unit of power, the *poncelet*, was 100 kgm. per second, the electricians' *kilowatt* was 102 kgm. per second. M. Berthelot objected to proper names being used for abstract units.—On analysis of the light diffused by the sky, by M. Crova. He made observations on the top of Mont Ventoux, with a modified form of his spectro-photometer, which could be directed to any part of the sky. The curves for zenithal light (alone examined) show a predominance of the more refrangible radiations at sunrise, diminishing towards midday, then increasing towards sunset; but not reaching, in homologous hours after noon, the same values as in the morning. The curves vary notably from day to day, with the state of the atmosphere. His figures show to what extent the light is bluer than the direct sunlight, and the light of the sky at Montpellier.—The Emperor of Brazil announced, by telegram, an observation of globular lightning on September 16.—Observations of Davidson's comet, with the bent equatorial (0·35 m.) of Lyons Observatory, by M. Le Cadet.—Observations of Brooks's comet and its companion, by the same. The nebulosity of the companion was elongated in the line of junction, and, at times, seemed to join the other.—On the determination of integrals of certain equations with partial derivatives by their values on a contour, by M. E. Picard.—Physiological researches on hydrocyanic acid, by M. N. Gréhant. Diminishing the force of the poison by dilution, &c., he found (in dogs and frogs), the heart-beats persist after the respiratory movements (gradually) stopped.—On the phosphorescent infection of *Talitrus* and other Crustacea, by M. A. Giard. On examining microscopically a brightly phosphorescent *Talitrus* he found walking slowly on the beach (instead of leaping like its companions), he traced the light to bacteria in its muscles, which were greatly altered. He inoculated other individuals (both *Talitrus* and *Orchestia*) with blood containing these microbes, and produced the disease with entire success. The laboratory cellar had quite a "fairy-like" aspect in the evening. The inoculations were continued to the sixth (luminous) generation, without attenuation, apparently, of the microbes' action. The disease follows a regular course; and the animal dies in three or four days, the phosphorescence lingering some hours after death. M. Giard also inoculated crabs successfully, and will describe results later.—On the metamorphosis and the migration of a free Nematode (*Rhabditis oxyuris*, Cls.), by M. R. Moniez. This animal is common in cow's dung. Young individuals fix themselves to the carapace of an Acarian (sometimes as many as sixty on one), by a chitinous plate (secreted from the anterior part) and short stem; then the tissues and organs shrink together from the transparent skin, forming a smaller ovoid body. When the dung dries, the Acarian, with these new larvæ on it, attaches itself to some insect, and is conveyed to fresh dung, where new transformations doubtless take place (not followed by the author). This was observed in August.—On the probable cause of the frondal bifurcations of ferns, by Dom B. Rimelin. When one of these anomalies is met with, others may generally be found quite near. The author thinks they must be due to fungi, *e.g.* of the family of Uredineæ; basing this induction on the diseased look where they are numerous, reproduction of the anomalies from sori of those divided ferns (considered with the fact that some parasitic fungi specially affect the organs of reproduction), &c.—Recent eruptive rocks of the Western Pyrenees, by MM. Seunes and Beaugey.

CONTENTS.

THURSDAY, OCTOBER 10, 1889.

THE SCIENCE COLLECTIONS AT SOUTH KENSINGTON.

THE English, like their American cousins, are a remarkable people, and in nothing more remarkable than in their toleration of incongruities.

They are gradually amassing at South Kensington an art collection which has but few rivals in the world, and the approach to it is shadowed by architectural monstrosities which, if regard is had to their position, are absolutely unrivalled. Within, they visit with apparent pleasure a hall decorated by the hand of Sir Frederick Leighton, and filled with the most exquisite masterpieces of Oriental art. Without, they are satisfied with the "Brompton boilers."

They concentrate, during a quarter of a century, collections to illustrate natural history, the physical sciences, and art, on one spot. They make it the head-quarters of State-aided education in science and art. Under the highest auspices a building is growing there, in which the products of the colonies are to be displayed to view. Close to it stands the Central Institute of the City and Guilds of London for Technical Education. Thus, in their own peculiar way, by apparently disconnected steps, and under the management of half-a-dozen independent, authorities, they evolve the noble idea of a great centre in which collections of all that is interesting, beautiful, and useful in the history and present applications of science and art shall illustrate, and be illustrated by, the researches and teaching of men like Profs. Huxley and Flower. They arrange a scheme by which the benefits are not confined to the metropolis only. The collections are circulated through the provinces, and provincial teachers are brought to the collections. Having done all this, they leave it in the power of one of the authorities—a set of irresponsible Commissioners—to cut into the heart of the site thus dedicated to science and art, with rows of stucco "mansions."

They house their natural history collections in a palace, and place its management in hands which have made it a palace of delight. They store invaluable collections to illustrate the progress of science and technology in sheds which are barely water-tight, and liable to burn like a tinder-box. They rely for their arrangement upon the "good-nature" of Professors of whose formal duties it forms no part, and upon the patriotism of men like Mr. E. A. Cowper, who, rather than see a good thing left undone, are willing, at great personal sacrifice, to do it themselves. Lastly, they leave questions as to the success of this haphazard system to be raised, not by some recognized scientific authority, but by the Treasury clerks.

Fortunately, as is so often the case in England, the results are better than the system. The suggestion that a great collection of scientific apparatus should be formed at South Kensington was made by the Duke of Devonshire's Commission. The ideal to be aimed at was defined by Commissioners appointed by the Science and Art Department, under the Chairmanship of Sir Frederick Bramwell. The Treasury, however, alarmed by "complaints of want of space in the galleries," recently determined to reconsider the matter for themselves, and appointed another Commission, which was, as it was doubtless intended to be, a very strong one. Had the Report, signed by the Treasurer of the Royal Society—Dr. Evans—as Chairman, by Lords Rayleigh and Francis Hervey, by Mr. Bernhard Samuelson, by Sir Douglas Galton and Sir Henry Roscoe, been adverse to the practical results attained by the collections, apart from the system under which they have been achieved, their opinion would doubtless have been regarded as conclusive. As it is, the Treasury will now have to bear in mind the following, which it will perhaps regard as inconvenient, facts.

The Commissioners were asked "whether there are any duplicates or other objects no longer essential to the value and representative character of the collections, which might be removed in order to provide additional accommodation for new objects of greater importance." They reply that "little, if any, space can be gained by weeding the existing collections."

They were requested to "investigate the existing practice of circulating scientific objects on loan to museums and schools so far as it affects the question of accommodation for storage or exhibition purposes at South Kensington." They reply that the space used for such purposes "has no practical bearing as to the housing of the collections."

They were not explicitly asked as to whether the existing museum accommodation is or is not adequate, but they assert that the question cannot be separated from those which were referred to them, and they recommend that, instead of the 60,000 square feet at present occupied, "an exhibition space of about 90,000 square feet should be provided without delay" in order to secure "a creditable Science Museum."

They also assume that this space will be covered with buildings "well arranged, well lighted, and of a durable character," a series of conditions which, as is evident to the casual visitor no less than to the Commissioners, is not fulfilled by some of those at present in use.

In short, the South Kensington Museum contains only objects which ought to be exhibited, in buildings *not* suited for their preservation and exhibition, and in space so cramped that it ought *without delay* to be increased by 50 per cent.

The Report was very well received by the daily press, and is certainly justified by the facts. It now only remains for public opinion to urge the Treasury to carry out the recommendations of its own Commission.

The Museum appears to be appreciated by the general public, and even to compete with the Natural History Museum on more equal terms than could have been expected. During the last four years there has been a steady increase in the number of visitors. In 1888 the Science Museum was inspected by 259,588, and the Natural History Museum by 372,802 persons.

Teachers under the Department are allowed, with certain reasonable restrictions, to bring their classes to the galleries, and to have the apparatus taken out of the cases for their inspection. The number of visitors who have thus had the cases opened for them, or in other ways have received special assistance in the galleries, has risen from 174 in 1880 to 1687 in 1888. The number of classes which have had the advantage of instruction illustrated by the apparatus which their teachers have been allowed to handle and to demonstrate, has increased from 7 in 1880 to 81 last year.

Every year 600 science teachers apply to be allowed to attend the summer courses held in the Normal School of Science. From these 200 are selected, and not only are the lectures which they attend illustrated by means of objects contained in the Museum, but they are able to inspect typical collections of apparatus, ready set up and arranged for the performance of the experiments which they are recommended in the Directory of the Science and Art Department to show to their classes.

It appears, then, that the full use of the galleries is not hampered by unnecessary restrictions. Permission to handle the apparatus is a privilege which does not suggest red-tape. Every effort is made to enable provincial teachers to share the advantages which may be reaped from the Museum, and it is casting no discredit upon the admirable provincial colleges which are springing up in our large towns to say that even a country like England could not gather more than one such collection as that which is being formed at South Kensington. Let us hope that the Report of the Commission has made it certain that, to the benefit of both town and country, the development of the collection will be promoted, and that before long it will be properly housed.

Although, however, the management of the Museum seems to have been satisfactory in practice, the Commissioners again travel outside the exact terms of reference to them, to express an opinion that the organization of the staff in charge of it requires revision. One of the Professors was specially examined on this point, and his opinion appears to be closely in accordance with the terms of the Report.

At present the responsibility for the collections lies primarily with the Lord President, and next to him with the Vice-President and the Secretary to the Science and Art Department. It is but one of the many proofs—which are often overlooked or ignored—of the ability with which the Department has been administered, that the Commissioners find no fault with the present state or future aims of the Museum. It is, however, impossible that collections so varied should be controlled without the help of experts, and, as matters stand, this assistance is sought in a more or less informal way from consultative Committees who have no real authority and no official responsibility. The results attained in some sections have been, for the most part, due to volunteers like Mr. Cowper, who has acted on several Committees of advice, and done the lion's share of the work, so that he "has been"—to quote his own words—"familiar with every one of the machines in the Department." The collections of scientific instruments are supervised by the Professors of the Normal School, whose advice is given subject to the limitations just described.

It would be premature to discuss the details of a scheme by which these arrangements might with advantage be superseded. A hearty admiration for the work which has been accomplished and for the ability of the officers of the Department under whose authority it has been carried out is, however, compatible with a no less hearty assent to the opinion of the Commissioners that "the system is defective in principle, apart from the personal qualities of those working under it," and that "the responsibility for the formation and supervision of these collections should certainly be of a more definite kind."

DARWINISM.

Darwinism. By Alfred Russel Wallace, LL.D., F.R.S. (London: Macmillan and Co., 1889.)

THE object of Mr. Wallace in writing the admirable work which he has published with the title of "Darwinism" has been "to give such an account of the theory of natural selection as may enable any intelligent reader to obtain a clear conception of Darwin's work, and to understand something of the power and range of his great principle." No one has so strong a claim as Mr. Wallace to be heard as an exponent of the theory of the origin of species, of which he is—with Darwin—the joint author. He has produced a thoroughly readable book, condensing into an octavo volume much of the speculation and description of important facts which are contained in the numerous volumes published by Darwin himself, and in the essays and occasional contributions of subsequent writers. Besides this, Mr. Wallace's book contains an exposition of highly important and interesting views of his own on subsidiary matters, which have either not been published previously or have appeared in a scattered and more or less inaccessible form. Consequently, the book is one which has interest not only for the general reader, to whom it is primarily addressed, but also for the more special student of natural history. The latter will find in its pages an abundance of new facts and arguments which, whether they prove convincing or not, are of extreme value and full of interest. If we attempt here to point out some of the shortcomings of Mr. Wallace's treatise, it is not from any desire to minimize its value and interest, but rather an acknowledgment of the weight and significance of a work on so important a subject by so specially competent an author.

Mr. Wallace's book necessarily suffers, in comparison with the works of Darwin himself, by the limitation of space. It is in consequence of this compression that we miss in the new statement by Mr. Wallace that extraordinary cogency or power of convincing which so distinguished the writings of Darwin. With Darwin one becomes accustomed to see no speculation put forward, no step of an argument advanced, unless there is an overwhelming weight of testimony in its favour: facts are cited in astonishing abundance, and at the same time the conviction establishes itself that the author has reserves of fact as rich as those of which he makes use, and further that he is so scrupulous and so modest that he will never ask his reader to accept a conclusion, however trivial, without stating fairly the amount of evidence for and against such conclusion. Mr. Wallace is prevented by the scope of his work from such treatment of his subject. As a result, his conclusions often appear to be (when they may not be so) based on very insufficient evidence, and his statement meagre. "Darwinism" can never take the place of the "Origin of Species," but may well serve as an introduction to the study of that and the other works of Darwin—the value of which, not only as storehouses of fact and suggestion, but as classical models of scientific discussion, cannot be over-estimated, and will probably never be surpassed.

In his preface, Mr. Wallace, through a misconception which is perhaps explained by the retired life which he enjoys—makes an attack upon what he calls "the modern school of laboratory naturalists." He states that these persons seek to minimize the agency of natural selection and to subordinate it to laws of variation, of use and disuse, of intelligence and heredity. He commends, as leading to truer views, the study of the external and vital relations of species to species in a state of nature—a study which Semper has called "the physiology of organisms," and I have proposed in the article "Zoology" in the "Encyclopædia Britannica" to call "bionomics." Now though there is no doubt an increasing number of younger students who have little or no interest in natural history beyond what is derived from the contemplation of ribbons of sections dyed like Joseph's coat, yet it is going too far to say that they have in any sense formed a school. And further, if we endeavour to estimate the influence on naturalists of a considerable devotion of time to the study in the laboratory of histology and embryology, physiology and morphology, we shall be led to the conclusion that this study has been associated with exactly opposite results from those attributed to it by Mr. Wallace. Who are they who seek to minimize natural selection and to set up the false gods of variation, use and disuse, &c.? Certainly not laboratory men. Is the Duke of Argyll a laboratory naturalist? Is Dr. George Romanes? Is Prof. Cope? Are Mr. Herbert Spencer and Prof. Patrick Geddes? I venture to say they are not; yet they are the authors with whom Mr. Wallace has subsequently to contend when he maintains that the selection of congenital variations by natural selection is an adequate theory of the origin of species, and requires no aid from Lamarckism, Copism, or other interlopers. Who are they who agree with Mr. Wallace in this contention? Precisely "laboratory men," who are, however, by no means *only* laboratory men, but, like Darwin himself, search for their material in the garden, the field, the seashore, or the sea-bottom; and as a part—but only a part—of their study of it eventually bring it to the laboratory. Such a "laboratory naturalist" is Weismann, whose essays and memoirs in favour of the identical view maintained by Mr. Wallace, appear to have escaped his attention until very recently. I presume also that I may claim to be a laboratory naturalist; and yet four years ago I found it necessary, in lectures delivered at the London Institution, to discard even that tincture of Lamarckism which Darwin had admitted, and to advocate "pure Darwinism," on the ground that the Lamarckian hypothesis is still devoid of experimental basis, and in view of the logical principal *Entia non sunt multiplicanda præter necessitatem*. It is true, as I have elsewhere insisted, that there are not at present such facilities for the study of bionomics as are provided in our laboratories for the study of histology, embryology, morphography, and the physics and chemistry of living bodies. But it is not right to identify the class of speculations, to which Mr. Wallace is opposed, with laboratory training. This, indeed, in virtue of its tending to bring speculation to the test of fact, is favourable, and often directly conducive, to the study of "the external and vital relations of species to species in a state of nature," or in one word "bionomics." I will only cite as instances Bateson's researches in Tartary, Caldwell's in Australia, Poulton's experiments on insects, and Moseley's "Notes of a Naturalist on the *Challenger*."

Mr. Wallace's plan of treatment of his subject is an excellent one. After a brief statement of what naturalists have understood by the word "species," and a lucid exposition of the views of the earlier transmutationists, he enunciates Darwin's theory. He then proceeds to show, by citing a wide and comprehensive array of facts, that the foundations of the theory are secure. In one chapter he describes the rapid multiplication of organisms and the consequent struggle for existence; in further chapters the fact of variability is shown, by an appeal to instances, to be one of the widest and most general character; in another chapter the facts of heredity and selection are brought forward. Then follow discussions of "difficulties and objections," hybridity, the origin and use of colour in animals and in plants, geographical distribution, the geological evidences of evolution, the fundamental problems of variation and heredity, and, lastly, Darwinism applied to man.

The chapter on "Variability of Species in a State of Nature" is one on which considerable pains has been expended. It presents some of the facts of variation in a very striking manner, and provides us with a number of well-studied instances which have not before been accessible to naturalists. A method followed by Mr. Wallace is to take any large collection of a single species and to measure various parts, such as length of head, tail, limb, &c. As he observes, it is very important to convince ourselves that variation does occur in a state of nature, so that natural selection has the material to act upon. He considers that the instances which he brings forward show that the range of variation is larger and more general in a state of nature than is usually assumed, and that "it is clear that Mr. Darwin himself did not fully recognize the enormous amount of variability that actually exists." Whilst admitting the interest of Mr. Wallace's present contribution to this subject, I think it is clear that he has failed to make a distinction which is desirable and important, viz. that between *variations* exhibited by adult specimens and the *variability* presented by the young of any given species. After all, the specimens of lizards and birds, of which the measurements are given to us by Mr. Wallace, only comprise such individuals as were *not too widely divergent* from the parent form to survive to maturity under conditions which select more or less closely a given specific set of characters. What one would like to know is the actual range of variability as shown by the artificial rearing of *all* the offspring of a single pair. With plants such a study of variation is practicable, but less so with animals. Variation includes those extreme cases which are called "monstrosities," and it is by no means certain that natural selection would *always* exclude these extreme cases from survival. The facts of variation under domestication are more to the point, in so far as the range of congenital variability is concerned, since in regard to a limited number of animals and plants we have removed the primary sifting of young forms. This sifting must occur under natural conditions, so as to allow only a limited range of variations to reach the collector in his museum. Clearly enough, this primary sifting, and all later operations of the same kind due to natural conditions, may under new circumstances be vastly modified in their nature, and variations may be allowed to pass the sieve which at another time are excluded. The range of variation, therefore, in even a very large museum series of a wild species, can afford but an inadequate notion of the variability of animals. We may, however, justly conclude that, if the former is so large as Mr. Wallace shows it to be, the congenital variations which occur, but never in given conditions reach maturity, must comprise instances which are very much more marked, and would furnish abundant material for natural selection were the natural conditions of the species to change. An attempt to determine by experimental rearing, the range of congenital variation (that is, of *possible* adult variation) in such animals and plants as are fitted for the inquiry, seems to be well worth making.

Mr. Wallace, who must have watched the early criticism of Darwin's theory with special keenness, makes a good point when he insists that the objection that it is difficult "to imagine a reason why variations tending in an infinitesimal degree in any special direction should be preserved" is a quibble. Darwin never used the word "infinitesimal," but spoke of variations being "slight" or of "small amount," and we agree with Mr. Wallace that even those terms are open to the objection that they may seem to imply that congenital variation is of less range and frequency than it really is.

Naturally enough, Mr. Wallace is not equally thorough in his treatment of each of the various "difficulties and objections" which he discusses, but the chapter thus headed gives an interesting summary of the present state of opinion. Among the matters discussed are the supposed smallness of variations, the doubt as to the right variations occurring when required, the beginnings of important organs, useless or non-adaptive characters, the instability of non-adaptive characters, the swamping effects of intercrossing, and the effects of isolation. In some of these instances Mr. Wallace's reasoning is very clear and forcible; in other cases it is much less so. Mr. Cunningham has already pointed out, in a letter to NATURE (July 25, p. 297) a curious slip on Mr. Wallace's part in his explanation of the gradual development of the twisted condition of the head and eyes of flat-fish. Mr. Wallace declines to admit the transmission of acquired characters as a cause of variation and progressive development; yet, apparently without being conscious of it, he attributes the movement of the eye of flat-fish from one side of the head to the other, to the transmission of a series of slight shiftings of the eye acquired in successive generations by the muscular effort of the ancestors of our present flat-fish, which is (to use an expression already known to the readers of NATURE) "flat Lamarckism." In relation to this, I may mention that the asymmetry of the Gastropod Mollusca, the forward position of the anus, and the twisted condition of the nerve-loop in the Streptoneurous division of that class, had been similarly attributed by myself to the cumulative effect of a mechanical cause—the one-sided lopping of the shell—operating in successive generations. Like Mr. Wallace, I had failed to notice that the explanation adopted was an admission of Lamarckism. It seems to me possible to explain the position of the flat-fish's eye by the selection of congenital variations, since there is no doubt of the advantage to the animal of having its two eyes on the one side of the body. But I confess that the Gastropods at present have not been satisfactorily explained. I have not been able at present (and I say at present advisedly) to find any evidence of advantage to the Gastropod in the torsion of its visceral hump, such as would justify the supposition that a monstrosity presenting this condition in full development was favoured by natural selection; still less does it appear how the steps of a gradual torsion—that is, a series of approximations to complete torsion—could be advantageous. It does not follow that we must admit Lamarckism; but merely that we must further examine Gastropod habits, structure, and development with this problem in mind.

Mr. Wallace does not, in my judgment, give sufficien grounds for rejecting the proposition which he indicate as the main point of Mr. Gulick's valuable essay o "Divergent Evolution through Cumulative Segregation." By the bye, Mr. Gulick is one of the heretics who attribut some part in the production of species to other cause than natural selection, yet he is not a laboratory naturalist but one who, substituting land-shells for butterflies, ha precisely the same foundations and training as M Wallace himself. Mr. Gulick's idea is that there is an in herent tendency to variation in certain divergent lines, an that when one portion of a species is isolated, even thoug under identical conditions, that tendency sets up a dive gence, which carries that portion further and further awa from the original species; or, in other words, no tw portions of a species possess exactly the same averag character, and the initial differences will, if the individua of the two groups are kept from intercrossing, asse themselves continuously by heredity in such a way as t insure an increasing divergence of the forms belongir to the two groups, amounting to what is recognized a specific distinction. Mr. Gulick's idea is simply the recog nition of a permanence or persistency in heredity, whicl *cæteris paribus*, gives a twist or direction to the variatio of the descendants of one individual as compared wi the descendants of another. Ireland is cited by M Wallace as an evidence that isolation has not been effe tive in modifying specific character of plants and anima If, however, unlike Mr. Wallace, we may look upon ma kind as subject to the same developmental causes, a only to the same causes, as animals, then Ireland wo seem to be a very interesting case of the production divergent character by isolation. All parties are agre that, whatever value is to be assigned to the fact, t human inhabitants of Ireland, whether of Celtic or Teuto ancestry, exhibit characters which are "divergent" fr those of the inhabitants of Great Britain, and, with going into details, we may say that the isolation a persistence of an original tendency seem to be the o explanation of the divergence.

The subject of "correlated variations" is but ligh touched on by Mr. Wallace, and its immense importa in relation to the whole question of "useless organs" useless characters of growth and structure is not sufficie put forward, as it was by Mr. Darwin. It is true that we know little about the physical basis of correlated variation, and are therefore open to hostile criticism when we take refuge in an appeal to it as an explanation of phenomena. The truth is that correlated variation is as important a property of living matter as heredity and variability themselves. It may be formulated thus: "Every departure from the parental form of any given part of an animal or plant is accompanied by a definitely correlated and often a commensurate departure in other parts remote from it." The possibilities thus introduced are simply gigantic—a new factor is brought in which extends the results of simple variation and selection indefinitely. In the future the laws and limitations of correlated variation will no doubt be determined. At present our knowledge of them rests where Mr. Darwin himself placed it. Both Mr. Gulick's doctrine of persistent hereditary tendency, and that of the immense capacities of correlation in variation, commend themselves to the mind of a laboratory naturalist who is accustomed to conceive of vital phenomena as mechanico-physical affections of a living substance, viz. protoplasm. They are, on the other hand, less valued—perhaps insufficiently—by Mr. Wallace.

In his chapter on the infertility of crosses, Mr. Wallace treats at length and with admirable effect a very important subject, as to which he is full of ingenious novel suggestions and apposite facts. His criticism of Mr. Romanes's essay, entitled "Physiological Selection," appears to me to be entirely destructive of what was novel in that laborious attack upon Darwin's theory of the origin of species.

The chapter on the origin and uses of colour in animals is that which will be most interesting to the general reader, and is indeed a charming essay, illustrated by numerous woodcuts. Here Mr. Wallace sets forth at length his convincing argument as to the use of colour as a means of recognition among animals, giving many examples—amongst others, that of the white patch on the rabbit's tail. In conjunction with his theory of the importance of the principle "like to like" in the segregation of varieties and the consequent development of new species, great significance must be attached both to the nervous organization, which makes recognition possible, and to the markings or other characters which are recognized. A very interesting discussion of Mr. Darwin's theory of sexual selection occurs in a subsequent chapter. Mr. Wallace, whilst admitting some of the effects of sexual selection recognized by Darwin, is not able to follow him in attributing to it the brilliant colours of birds and butterflies. Mr. Wallace attributes the deeper or more intense colouring of the male, which often occurs, to his "greater vigour and excitability." The female in many groups retains the primitive and more sober colours of the group for purposes of protection. The occurrence of colour itself in patches and lines is attributed by Mr. Wallace (following the late Mr. Alfred Tylor) to the distribution of subjacent nerves and blood-vessels, which follow, like the colour-patches, in the main, certain lines determined by the general structure. Mr. Wallace seems scarcely to have succeeded in showing that Darwin's theory of sexual selection is inapplicable to the explanation of special developments of colour and ornament, although he has suggested additional causes which influence the primary distribution and development of colour.

We have not space to speak of subsequent chapters on colour in plants and on geographical distribution, concerning the latter of which subjects Mr. Wallace speaks with every title to respect, and suggests some novel views. On the "Geological Evidences of Evolution" as well as on the "Fundamental Problems" of variation and heredity, he is less satisfactory. In regard to the latter, one chapter is altogether an inadequate space in which to deal with such an array of antagonists as Mr. Herbert Spencer, Dr. Cope, Dr. Karl Semper, and Mr. Patrick Geddes. Mr. Wallace has barely space to do more than state his opponents' views, and to give a rapid summary of reasons for his dissent, without sufficiently establishing those reasons. This will be especially regretted by those who, like myself, agree with Mr. Wallace in his rejection of Spencer's and Semper's Lamarckism, and are unable to attach any serious value to the speculations put forward on this matter by Dr. Cope and Mr. Geddes. The translation of Weismann's "Essays," which appeared coincidently with Mr. Wallace's book—although many of the essays have been for some years familiar to readers of German—supplies that more solid treatment of the subject which is desirable. It is satisfactory to find that justice is done by Mr. Wallace to Mr. Francis Galton, whose views on heredity, arrived at by a special method of inquiry, are closely similar to those arrived at on other grounds by Weismann.

Prof. Semper's work "On the Natural Conditions of Existence as they affect Animal Life" is duly mentioned by Mr. Wallace, and he does not fail to notice the striking fact that in this interesting volume the author entirely fails—as I pointed out in NATURE when it appeared—to adduce a single fact in proof of the Lamarckian theory which he sets out to champion.

Of the American evolutionists Mr. Wallace justly says: "In place of the well-established and admitted laws to which Mr. Darwin appeals, they have introduced theoretical conceptions which have not yet been tested by experiments or facts, as well as metaphysical conceptions which are incapable of proof." They have, in fact, conspicuously abandoned the "scientific method."

The words which Mr. Wallace has applied to the American evolutionists are, in the opinion of many, strangely applicable to portions of his own concluding chapter on "Darwinism applied to Man." He here introduces us to a "spiritual world" and to "different degrees of spiritual influx." Mr. Wallace is in the peculiar position of one who believes that he has experimental evidence of the remarkable theoretical and metaphysical conceptions which he introduces. He boldly takes up this position, and we may be sure that he would not wish attention to be diverted from it. It remains an interesting problem for the future student of human faculty to reconcile Mr. Wallace's wonderful ingenuity and skill as a reasoner and observer concerning animal life, with his views as to the so-called "manifestations" of spiritualists.

Mr. Wallace's contention that the mathematical, musical, and artistic faculties of man have not been developed under the law of natural selection must in large part be conceded. Whilst the earlier development of these faculties may be explained as due to natural selection since some amount of each may well have been an advantage to the primitive man in his struggle for existence, it is yet true that their sudden and rapid development to a very much higher level in civilized communities cannot be traced to the struggle between man and man. It does not, however, follow that, because natural selection will not account for these extraordinary developments of the human brain, therefore we must have recourse to the assumption of supernatural agencies. Mr. Wallace seems so much convinced of the importance and capability of the principle of natural selection, that when it breaks down as an explanation he loses faith in all natural cause, and has recourse to metaphysical assumption. On the other hand, it must be contended that we know very little of the development, either in the individual or in various races, of these and other faculties of the mind. The formation of civilized communities has had the result of withdrawing the individual man almost entirely from the operation of natural selection. Such selection as still obtains operates by the struggle of communities rather than by that of individuals. Accordingly there is a possibility of the most useless "sports" making their appearance, and even establishing themselves in human communities as hereditary qualities. Mr. Gulick's notion that an initial tendency due to accidental variation can increase and develop in succeeding generations, without reference to the advantage or disadvantage of the species, would assuredly be applicable, if anywhere, to the human mind in communities where individuals are no longer subject to natural selection, or only to a minimal extent, and in relation to a few points of structure. Does the luxuriant development of some Professor's mathematical faculty, as compared with the poor numerical conceptions of an Australian black, offer really any greater difficulty of transition than do the 9-feet-long tail feathers of some Japanese barn-door fowls, as compared with the shorter feathers of other varieties? That is a question which can only be answered by a more elaborate analysis of the nature of the qualities compared than has, so far as I know, been hitherto accomplished.

E. Ray Lankester.

GALTON'S AFRICAN TRAVELS.

Narrative of an Explorer in Tropical South Africa; being an Account of a Visit to Damara Land in 1851. By F. Galton. With *Vacation Tours in* 1860 *and* 1861, by Sir George Grove, F. Galton, and W. G. Clark. (London: Ward, Lock, and Co., 1889)

THE editor of the Minerva Library has added Mr. Francis Galton's "Narrative of an Explorer in Tropical South Africa" to a library consisting only of "works of the most widely-spread and lasting popularity, which have proved themselves worthy of a permanent place in literature." Had the stamp of popularity not been so precisely insisted upon as a title to admission into this particular series, it might have been his gracious task, now and then, to have rescued from oblivion a stray work which had failed to obtain recognition from causes in no way affecting its intrinsic merits. Books of travel, for instance, have often suffered from inopportune publication, and, being out of season, have fallen flat and unheeded; whereas, if introduced a quarter of a century later, they would have been welcomed by an expectant public, educated for the occasion. But the condition, as it now stands, relieves the editor from a difficult and somewhat delicate responsibility, the adequate discharge of which might well need the exercise of more than one man's judgment and experience. Fortunately for the book under notice, it fulfils all the professed requirements of Mr. Bettany's prospectus. It presents quite a model in respect of style, and is essentially the production of a master mind. The writer lucidly recounts his experiences for the instruction as well as entertainment of his readers, and the outcome of his labour is a success to himself and a benefit to his fellows. His narrative is interesting and well sustained; his descriptive powers are manifestly considerable; his appreciation of men and things, the animate and inanimate, is admirable; and he is realistic to the legitimate extent of insuring credence for a record of personal adventure not untinged with romance.

Independently of these considerations, however, there is another reason why the reproduction of Mr. Galton's book at the present hour is practically useful. He treats of a particular section of Africa which has hardly received its fair amount of attention from the politicians and geographers of Europe, when discussing the great partition question of the day. The Congo has had the lion's share of solicitude as regards the western coast-line; while the spirited and intelligent action of the British East African Company, and movements of rival or contemporary Companies, have resulted in throwing, as it were, a broad bright light upon the whole length of eastern sea-board from Guardafui to the Zambesi. Names such as Mombasa and Vitu are becoming familiar as Zanzibar and Mozambique, and the practical effect of Messrs. Johnston and Thomson's successful journeys has been to introduce into our school teaching the true stories of Kilimanjaro and the Masai Land. Below the Congo there has been little demand for information, and consequently little supply. The knowledge that Portugal is owner of the coast-line from the much-coveted mouth of that river to that of the Kunene, has appeared sufficient to render Benguela and Mossamedes, with their inland territories and contiguous tracts, matters of secondary interest; and below Mossamedes nothing but a political embroglio has caused Walfisch Bay and Angra Pequena to emerge from out the haziness of quasi-mythical places. Mr. Galton's narrative will not only be found instructive in itself, but it cannot fail to lead the uninitiated reader into references and inquiries also full of enlightenment; and even those who are well up in African geography, and may have read the book on its first appearance, will most probably derive advantage in reverting to its pages. The part of the Dark Continent comprehended in its treatment is from somewhere near the mouth of the Kunene to the mouth of the Orange River, and may be roughly indicated by a figure to which the parallels 17° and 27° S. latitude give a northern and southern boundary, and the meridians 12° and 20° longitude western and eastern limits. In the appendix much of the exploration of later years is reviewed, and the names of Messrs. Anderson and Coates Palgrave, Lord Mayo, and Père Duparquet of the Huilla Mission are honourably mentioned. Those of Drs. Höpfner and Stapff might have been added, bringing up to May 1886 the roll of authorities whose labours need only some new political complication to become of palpable value. Moreover, it may here be parenthetically stated that the West African Telegraph Company have recently prolonged their cable south of St. Paul de Loanda, opened as a station in 1886—a proceeding which should facilitate the acquisition of much new geographical information in connection with the region specified. Already has a contribution from one of its officers appeared in the Proceedings of the Royal Geographical Society, from which we learn that the harbour of Mossamedes is only second to that of Loanda among the harbours of Western Africa, and that the latter, possessing less depth of water, and being smaller, suffers in the comparison. Benguela is described as the more important commercial port, the total amount of its annual imports and exports (£268,398) being nearly four times more than those of Mossamedes.

Now that thirty-nine years have passed since this exploration was undertaken it may be well to recall its extent and character. As apparent from the map illustrative of his labours, Mr. Galton moved in a north-easterly direction from Walfisch Bay to Barmen, journeying a distance of nearly 200 miles. After an excursion from that place—called "the head seat of intelligence as regards Damara and Hottentot movements"—he struck off to Ovampo Land in the north by a route involving a slight detour to the east. But before making a fair start from Schmelen's Hope (a point somewhat further inland than Barmen), he was led by circumstances to Eikhams and Rehoboth in the south; and part of the return road from Ondongo, the *ultima Thule* of his northerly journey, was by a track other than that he had at first pursued. From the date that his waggons left Schmelen's Hope to that of their return, a period of exactly five months elapsed. Of these, we are told that "ninety days were employed in journeying onwards, independently of such excursions as were made from time to time to look out for roads." The return distance is reckoned at about 462 miles, the average rate of travelling being nine and a half miles a day—fair indeed with a more or less improvised carriage, barbarous retinue, and tired or hungry and thirsty bullocks.

Some notion of the privations endured may be gathered from our traveller's statement that, on his leaving Schmelen's Hope for Ovampoland, his "biscuit and every kind of vegetable food had been eaten up"; or, as later expressed, he had "no biscuit, no flour, or anything of the sort." He and his party had to live on the oxen and sheep they possessed, and the game they contrived to shoot on the way, so that grain-food was a special luxury. Milk, though used in profusion by the Damaras, could rarely be purchased from them, owing to some impeditive superstition. Their ordinary *pabulum*, pig-nuts, was "worthless and indigestible," inasmuch as it should be "eaten in excessive quantities to afford enough nourishment to sustain life." As to water, this was a more serious matter still. On some days it utterly failed; on others it was brackish, or barely drinkable—as may be inferred from the following description of a *vley*, or watering-place:—

"Fancy a shallow pool, from 10 to 20 yards across, and from 6 to 12 inches deep, in which a herd of wild animals, say fifty zebras, have been splashing and rolling themselves all night, and which they have left in every respect like the water pumped out of a farmyard; and, where wild animals are wanting, the oxen, in spite of every precaution, will do the same."

The sporting adventures of the book are especially remarkable. It is not improbable that more than one tender-minded reader will accord sympathy to a wounded giraffe hunted to the death, or a dog slain for the sake of its skin—both occasions illustrating an act perpetrated to satisfy the pressing wants of man. Few, however, can fail to appreciate the manly qualities of a traveller whose career in Africa brings him into frequent and willing contact with the lion, rhinoceros, hippopotamus, elephant, and those larger and more formidable animals contention with which is risk of limb and life. The same stout-heartedness is exhibited in his intercourse with the savage inhabitants of the tracts through which he moves, and in the fearless but efficient diplomacy which characterizes his dealings with Bushman and Hottentot, Namaqua, Damara, Ovampo, or whatever the designation of those with whom he has to do.

Not the least exciting part of Mr. Galton's narrative will be found in the penultimate chapter. At this time he had retraced his steps from Ovampo Land to Barmen. Instead, however, of continuing his return journey to the coast, he resolved to devote three and a half out of the four months which would necessarily intervene before the arrival of an expected schooner in Walfisch Bay, to an expedition to the eastward, for the double purpose of seeing something of the Hottentot inhabitants, and ascertaining how far correct was the statement that the Karrikarri Desert was "interposed as an impracticable barrier between the sea-coast countries and Lake 'Ngami." The following extract from this particular chapter (pp. 168–69) furnishes a good specimen of the writer's descriptive powers. He and his associates had just repaired some circular walls of loose stones intended to serve as shooting-screens:—

"It is one of the most strangely exciting positions that a sportsman can find himself in, to lie behind one of these screens or holes by the side of a path leading to a watering-place so thronged with game as 'Tounobis. Herds of gnus glide along the neighbouring paths in almost endless files; here standing out in bold relief against the sky, there a moving line just visible in the deep shades; and all as noiseless as a dream. Now and then a slight pattering over the stones makes you start; it jars painfully on the strained ear, and a troop of zebras pass frolicking by. All at once you observe, 20 or 30 yards off, two huge ears pricked up high above the brushwood; another few seconds, and a sharp solid horn indicates the cautious and noiseless approach of the great rhinoceros. Then the rifle or gun is poked slowly over the wall, which has before been covered with a plaid, or something soft, to muffle all grating sounds; and you keep a sharp and anxious look-out through some cranny in your screen. The beast moves nearer and nearer; you crouch close up under the wall, lest he should see over it and perceive you. Nearer, nearer still; yet somehow his shape is indistinct, and perhaps his position unfavourable to warrant a shot. Another moment, and he is within 10 yards, and walking steadily on. There lies a stone, on which you had laid your caross and other things, when making ready to enter your shooting-screen; the beast has come to it, he sniffs the taint of them, tosses his head up wind, and turns his huge bulk full broadside on to you. Not a second is to be lost. Bang! and the bullet lies well home under his shoulder. Then follows a plunge and a rush, and the animal charges madly about, making wide sweeps to right and left with his huge horn, as you crouch down still and almost breathless, and with every nerve on the stretch.

"He is off; you hear his deep blowing in the calm night; now his gallop ceases. The occasional rattling of a stone alone indicates that he is yet a-foot; for a moment all is still, and then a scarcely audible 'sough' informs you that the great beast has sunk to the ground, and that his pains of death are over."

The author has long since been so well known as a gold medallist and leading member of the Royal Geographical Society, and for his important contributions to anthropology and other departments of science, that it would be superfluous at this time to dwell on the value of his explorations, compared with those of the ordinary and less-gifted traveller. His exceptional aptitude for what may be called professional travel is well exemplified at pp. 180–82 of the volume now republished, in which, among other useful hints, he gives plain and practical instructions for selecting the best sort of travelling compass and checking distances and directions. His manual on the "Art of Travel" has for many years been a standard work of reference; while no one who reads, in the "Narrative of an Explorer," his amusing record of "a series of observations" taken by sextant upon the figure of a Hottentot lady—with results worked out "by trigonometry and logarithms"—can affirm that his sense of humour has been blunted by scientific pursuits.

A republication of "Vacation Tours in 1860 and 1861" —papers by Sir George Grove and the late Mr. W. G. Clark, added to one by Mr. Galton—enhances the value of this new accession to the Minerva Library.

OUR BOOK SHELF.

Practical Photometry: a Guide to the Study of the Measurement of Light. By W. J. Dibdin. (London: Walter King, 1889.)

THIS work forms a good practical text-book on the art of photometry, which, both scientifically and commercially, is becoming more and more important. It contains a comprehensive account of the various methods in daily use, so that the student, when he finds that he is dealing with instruments and methods unfamiliar to him, may turn to this book as a guide to the many precautions necessary to insure accurate results. The first few chapters deal with the history and principles of photometry, together with horizontal, radial, and jet photometers, and diagrams are given of the determinations of the quantity of light afforded in all directions horizontally by three classes of flames tested at every 10°, and also of Dr. Pole's method of expressing the illuminating power and rates of consumption per hour of fifteen-candle gas. In chapters vi. and vii. we have a discussion on the various standards of light which have been and are still in use, followed by the numerous proposed substitutes, such as Harcourt's pentane, Sugg's sixteen-candle argand, Methuen's screen, &c. The apparatus necessary to check and measure the flow of gas to the standard burner is given in chapter viii., with detailed descriptions. Chapters ix. and x. treat of "The Examination and Adjustment of a Gas-testing Photometer" and "Colour Photometry," the latter dealing with methods of estimating the colour and intensity of the illumination of fabrics, &c. Lastly, in chapter xi., on "Stellar Photometry," the author gives an account of the methods employed by Sir John Herschel, Zöllner, and others, concluding with a description of a method proposed by himself.

The appendix contains some useful pieces of miscellaneous information, and tables of illuminating power of sperm candles, candle corrections, &c. The work is well illustrated with numerous woodcuts of the various instruments employed.

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 Testing of Colour-Blindness.

THE important article in NATURE of September 5 (p. 438) will have been read by all friends of education with deep and melancholy interest.

I desire to point out that the real remedy ought not to be dealt with by an Act of Parliament, partly because this is a makeshift, and partly because the sudden dismissal of a trained seaman for a constitutional defect is so cruel that human nature would get very much in the way of such an Act of Parliament.

What is wanted is that the colour sight and other measurable faculties of youths should be tested before they go out into life. It is a detail of practical anthropometry. Just as no parent would think of encouraging his son to become a barrister when he knew that he stammered or was deaf, so no parent would waste money in training his son to be an engine-driver or a sailor when he knew—as he ought to know—that the lad was colour-blind.

I protest against a defect of our educational system being treated as a defect of legislation or of administration, and I trust that the friends who seek that scientific education should have its due place will move in this direction, and thus prevent the cruelty to seamen and their families as well as the deaths of their fellow-creatures which are at present possible from the causes indicated in your article.

I desire to ask if some of your readers will kindly furnish information, through your columns, as to where the colour-tests can be obtained, their cost, and the literature respecting them.

9 King Street, Oxford, September 19. J. F. HEYES.

Mites.

IN the grounds of the Leicester Museum there are some half-dozen young lime trees, about fifteen years old, of which the trunks and under sides of the main branches are covered with an extremely thin glistening film. It seems to consist of a similar material to that of which spider's web is made, but spread out into a film instead of being spun into thread. When rubbed up it has all the appearance of spider's web similarly treated. But there are no spiders visible, except here and there an Epeira, who has fixed his geometric web to some protuberances on the trunk.

The bark, however, is thickly dotted over with small yellowish mites, very similar to cheese mites in size, form, and colour. Some of these mites are creeping on the outside of the film also, and a few of them are captured in the webs of the Epeira. No other trees appear to be affected except the limes, and only one particular row of these. I have found a few of the mites, but no film, on other limes in the grounds, but none on horse-chestnuts or laburnums which stand nearer to the affected trees.

How has this film been produced? and are the mites connected with it as cause or effect? F. T. MOTT.

Leicester, September 23.

Sailing Flight of Large Birds over Land.

THE explanation of this, in NATURE (p. 518), seems inadequate.

If a large body of air be moving uniformly both in respect of direction and of velocity, no matter at what rate, it might as well be perfectly motionless, in respect of its ability to aid the flight of a bird that is simply floating in it. But in fact the air never is motionless: it moves with the earth, from west to east, at the rate, let us assume, of 500 miles an hour. To a bird floating in the air, whether the earth beneath it moves exactly as the air moves, or not, must be a matter of perfect indifference. The earth's relative motion does not affect it. I must myself adhere to the explanation which I gave in a former number of NATURE (vol. xxviii. p. 28), that the birds avail themselves of differences of the movement of the air, in respect of velocity, or of direction, or of both. Mr. S. E. Peal has noticed that "flocks which drift over the hills recover their position on the plains by descending to windward." This is simple enough. The wind is flowing from the plains towards the hills. It rises then as it flows, and has many inequalities in its direction and rate. On entering a gorge a narrow current of air would be thrown upwards with very rapid ascent. Of all the inequalities the birds know how to avail themselves. R. COURTENAY.

Tean Vicarage, September 28.

A Remarkable Meteor.

ON Sunday, September 29, at 7.30 p.m., I observed a very brilliant meteor falling nearly perpendicular a little to the west of north. Its progress towards the earth appeared to be much slower than is usually the case with such bodies, the heavens being illuminated for several seconds. The meteor was of a bright sapphire hue; preceding it were a few drops of bright fiery red, whilst following it came a brilliant trail of light. It seems to have been pretty generally observed throughout Ireland, and letters to the Press from counties Roscommon, Galway, Kilkenny, and Kildare, testify to the interest it has awakened in the country. RICHARD CLARK.

113 Upper Leeson Street, Dublin, October 7.

THE METHOD OF QUARTER SQUARES.[1]

THE method of quarter squares consists in the use of the formula

$$ab = \tfrac{1}{4}(a + b)^2 - \tfrac{1}{4}(a - b)^2$$

to effect the multiplication of two numbers, a and b. If we are provided with a table giving the values of $\frac{1}{4}n^2$ up to a given value of n, we may obtain, by the aid of this formula, without performing any multiplication, the product of any two numbers whose sum does not exceed the limit of the table.

The method is specially interesting on account of the great simplicity of the formula, by means of which a table of double entry may be replaced by one of single entry. How great a transformation is effected by such a change is evident, if we consider that the largest existing multiplication table of double entry reaches only to 1000 × 1000, and forms a closely-printed folio of 900 pages, but that a table of quarter squares of the same extent (*i.e.* of $\frac{1}{4}n^2$ up to $n = 2000$) need only occupy 4 octavo pages. The disparity becomes even more conspicuous as the limit of the table is extended, for a table of double entry extending to 10,000 × 10,000, would require nearly 100 folio volumes; and one extending to 100,000 × 100,000, would require nearly 10,000 volumes; whereas the corresponding quarter-square tables need only occupy 40 and 400 octavo pages respectively.

The use of a table of squares in effecting multiplications was recognized as far back as 1690, when Ludolff published his large table of squares, extending to 100,000. In the introduction to the table Ludolff explained how it could be employed in multiplications. In order to multiply a and b the table is to be entered with $a + b$ and $a - b$ as arguments, and the difference of the corresponding squares divided by 4. If a and b are both even, or both uneven, their sum and difference will both be even numbers, so that $\frac{1}{2}(a + b)$ and $\frac{1}{2}(a - b)$ will be integers. In either of these two cases we may therefore enter the table with the semi-sum and semi-difference of the numbers as arguments, the product being the simple difference of the corresponding squares.

It was not, however, till 1817 that a table of *quarter* squares (*i.e.* of $\frac{1}{4}n^2$ for argument n) was published, for the purpose of facilitating multiplications. If n be uneven, $\frac{1}{4}n^2$ consists of an integer and the fraction $\frac{1}{4}$. This fraction $\frac{1}{4}$ may be ignored in the use of the table, for if either $a + b$ or $a - b$ is uneven, the other is so too; the fraction $\frac{1}{4}$ therefore occurs in both squares, and disappears from their difference. It may therefore be omitted from the table.

The table of 1817, which contained the first practical application of the method, was published by Antoine Voisin, at Paris, under the title "Tables des Multiplications; ou, Logarithmes des Nombres entiers depuis 1 jusqu'à 20,000." It is curious that Voisin should have called a quarter square a logarithm: he called a the root, and $\frac{1}{4}a^2$ its logarithm. His table extended to 20,000, and was thus available for multiplications up to 10,000 × 10,000. On the title-page Voisin described it as effecting multiplications up to 20,000 by 20,000. This statement is justified by the formula

$$ab = 2\{\tfrac{1}{4}a^2 + \tfrac{1}{4}b^2 - \tfrac{1}{4}(a - b)^2\},$$

by which the product was to be obtained if the sum of the numbers exceeded 20,000, the method of quarter squares being then no longer available. It is to be observed, however, that this formula requires three entries besides the final duplication.

Almost simultaneously (1817) a similar table, of the same extent, was published independently by A. P. Bürger at Carlsruhe. The method was rediscovered by J. J. Centnerschwer, who published a table of the same extent in 1825 at Berlin. In 1832, J. M. Merpaut published, at Vannes, a table of quarter squares extending to 40,000. In 1852, Kulik (well known for his large table of squares and cubes to 100,000), who had again rediscovered the method, published a table extending to 30,000. In 1856, Mr. S. L. Laundy published, at London, the largest table of quarter squares which had appeared previous to the publication of the present table. Laundy's table extends to 100,000. It was intended that the multiplications should be effected by means of quarter squares if the sum of the numbers did not exceed 100,000, but other five-figure numbers were to be multiplied by means of Voisin's three-entry formula referred to above.

It is this change of method that has detracted so greatly from the value of Laundy's fine table. It is evident that the table should have been carried to double its actual extent, *i.e.* to 200,000, so that any two five-figure numbers could be multiplied together by means of the two-entry formula. The late General Shortrede constructed such a table, but it was never printed. In the work under notice Mr. Blater carries the table as far as 200,000; so that, more than sixty years after the publication of the first table effecting the multiplication of two four-figure numbers, the extension to five figures has at last been completed.

The method of quarter squares has had no opportunity of a fair trial in the absence of a table extending to 200,000. Considering the many purposes to which Crelle's tables (which give the product of any two three-figure numbers by a single entry) are continually applied, it is perhaps surprising that no general use should ever have been made of a table which in a very small compass gives, by only two entries, the product of two four-figure numbers. Still it is clear that the full power of the method

[1] "Table of Quarter Squares of all Whole Numbers from 1 to 200,000 for simplifying Multiplication, Squaring, and Extraction of the Square Root, and to render the Results of these Operations more certain." Calculated and published by Joseph Blater. (London: Trübner and Co., 1888.)

is not felt till we are provided with such a table giving the product of two five-figure numbers. As already stated, the fact that the limit of Laundy's table was only 100,000 has deprived it of most of its value, for it is obvious that, unless all five-figure numbers can be treated by a uniform method, the table could not be conveniently employed in practice.

Mr. Blater's work consists of the principal table (giving quarter squares up to 200,000), which occupies 200 pages; a small table of four pages, called the index, to facilitate the use of the table in the extraction of square roots; and an introduction, &c., of fourteen pages.

The arrangement of the table (in which the author has followed the plan adopted by Kulik in his table of 1852, already referred to) is somewhat peculiar. The table is first entered (*i.e.* the required page of the table is found) by means of the *last* three figures of the number: the table is then entered on this page (or, more correctly, double page), by means of the preceding figures. For example, the quarter square corresponding to 126,993 is found by turning to the double page headed 990. In one of the four columns headed 993 we enter the table at the line 126: from this line we obtain, in the first column, the first four figures of the result, 4031; in the column under 993, the next three, 805; from the bottom of the column we take the last three figures, 512. The result is therefore given in three parts A, B, C; A being common to ten numbers (in the same line) beginning with 126, C being common to fifty numbers (in the same column) ending with 993, and B being special to the combination 126,993.

The table is beautifully printed in large antique figures on thick and excellent paper, and is a handsome piece of typography. The author mentions that it was entirely set up by a single compositor at the printing-office of Mr. Falk, at Mayence, and that it occupied his whole time for eleven months. Besides being admirably printed, the table is no doubt very correct, as a triple calculation was made, and no pains seem to have been spared by Mr. Blater for insuring accuracy.

The book is dedicated to Mr. Anthony Steinhauser, of Vienna, who has contributed a short historical preface. Mr. Steinhauser, who is himself the author of several logarithmic tables, encouraged Mr. Blater in his work, and rendered him great assistance throughout. The actual calculation occupied eighteen months.

With respect to the general employment of Mr. Blater's table for the performance of multiplications, it is to be feared that its utility has been jeopardized by the size of page adopted. Anyone who has had occasion to make constant use of tables knows the enormous advantage of the octavo form over the quarto. The book is placed to the left of the computer, and the effort of carrying by the eye a series of figures from the left-hand page of a quarto table to the paper—a distance of 18 inches to 2 feet—is but ill compensated for by larger figures or fewer pages. Handsome as the book is to look at, it seems to us that the table would have had much more chance of bringing the method into general use if it had been of octavo form. It is greatly to be regretted that it was not printed on 400 octavo instead of 200 quarto pages, which would have been quite possible with the existing arrangement of the table. If this had been done, and if the type had been somewhat smaller, a neat and handy volume might have been produced.

The mode of entering the table is very insufficiently explained in the introduction. This is unfortunate, as the mode of entry (by the last figures) is so unusual in tables that it should have been explicitly mentioned. Also the translation into English is so very unsatisfactory as to be obscure in places. These, however, are minor blemishes which would have but slight influence on the general utility of the table, if only the form were convenient.

The question of how far the method of quarter squares is likely to come into use is of some interest. Hitherto the method has been very little known, and, so far as we know, it has never been used in practice on any extended scale. The mere fact that it has been so constantly discovered anew is sufficient evidence of the slight attention that it has received. Still, there ought to be room for a table that gives, to the last figure, the products of any two five-figure numbers with only two entries. A seven-figure table of logarithms is inadequate for this purpose, for, besides requiring three entries, it only gives the first seven figures of the result. On the other hand, it may be said that in ordinary calculations seven figures are as many as are required, and that logarithms possess the advantage of being equally convenient for divisions and multiplications. It must be admitted that a five-figure quarter-square table is appropriate to only a limited class of calculations: it applies only to multiplications, and the number of figures in each of the two numbers must not be greater than five. These conditions are of a somewhat special kind. In recent years when heavy multiplications have been required it has become the custom to make use of Thomas de Colmar's arithmometer; and probably, at the present time, nearly all systematic work of this character is carried out either by Crelle's tables or by the arithmometer.

Passing now to the general question of multiplication by means of a table of single entry, we have the two methods of quarter squares and logarithms, each possessing its special advantages. There is also an older method which passed out of notice with the invention of logarithms. This method was called "prosthaphæresis," and depended on the formula

$$\sin a \sin b = \tfrac{1}{2}[\sin\{90^\circ - (a - b)\} - \sin\{90^\circ - (a + b)\}].$$

A table of natural sines could therefore be used as a multiplication table, four entries being required. This method is due to Wittich, of Breslau, who was assistant for a short time to Tycho Brahé, and it was used by them in their calculations in 1582. It is referred to by Raymarus Ursus, Clavius, and Longomontanus; and it seems to have been used for performing multiplications not only when the numbers occurred as sines but also in the case of ordinary numbers.

The method of quarter squares depends upon so simple a formula, that it is strange that the first table should not have appeared until 1817. There seems no reason why it should not have been employed before the invention of logarithms, when it would have been a most valuable aid to calculation. The geometrical theorem, which is equivalent to the algebraical identity $(a + b)^2 - (a - b)^2 = 4ab$, on which the method depends, forms Prop. viii. of the second book of Euclid; and one would think that the application of the geometrical or algebraical theorem to arithmetic might have been noticed at any time. The actual history of mathematical tables is, however, entirely different from what we might expect it to have been, owing to the wonderfully early invention of logarithms: and it was, in fact, only just about that time that the importance of tables as an aid to general calculation was beginning to be felt. The date of Herwart ab Hohenburg's great double-entry multiplication table, extending to 1000 × 1000 (the same limit as Crelle's table, and which has never been exceeded) is only four years earlier (1610) than that of Napier's "Canon Mirificus" (1614).

It is interesting to notice that the method of quarter squares is more closely connected mathematically with the method of prosthaphæresis than with that of logarithms; in fact, from the formula

$$\sin a \sin b = \tfrac{1}{2}\{\cos(a - b) - \cos(a + b)\},$$

we readily deduce

$$ab = \tfrac{1}{4}\{(a + b)^2 - (a - b)^2\},$$

by expanding the sines and cosines in ascending powers of their arguments and equating the terms of two dimensions.

The method of quarter squares enables us to multiply together two numbers of n figures each if we have a table extending to 2×10^n. If the latter only extends to 10^n three entries are required, and the final result has to be doubled whenever the sum of the numbers exceeds $10n$ (as in Laundy's table). If we consider the question of the multiplication of two numbers of n figures each by means of a table extending only to 10^n, the same process being employed in all cases, it appears that three entries are necessary, and that it would be better to tabulate half squares, using the formula

$$ab = \tfrac{1}{2}a^2 + \tfrac{1}{2}b^2 - \tfrac{1}{2}(a-b)^2,$$

In tabulating the half squares the fraction $\frac{1}{2}$ would be thrown off, so that if a and b were both uneven, unity would have to be added to the result.

It would, however, we think, if the table is not to go beyond 10^n, be more convenient to employ a table of triangular numbers. The nth triangular number is $\frac{1}{2}n(n \times 1)$, and if we are provided with a table extending to 10^n we may multiply any two numbers not exceeding 10^n by means of the formula

$$ab = \tfrac{1}{2}(a-1)a + \tfrac{1}{2}b(b+1) - \tfrac{1}{2}(a-b-1)(a-b);$$

or, as we may write it

$$ab = \mathrm{T}(a-1) + \mathrm{T}(b) - \mathrm{T}(a-1-b),$$

$\mathrm{T}(n)$ denoting the nth triangular number.[1]

Thus, to multiply two numbers we subtract unity from the larger number, and enter the table with the larger number so diminished, with the smaller number, and with the difference of these two numbers. For example, to multiply 5289 and 2156, we add the tabular results corresponding to 5288 and 2156, and subtract from this sum the tabular result corresponding to 3132.

The mode of construction of a table of triangular numbers is almost the simplest possible, the numbers being formed by adding to zero the natural numbers 1, 2, 3, ... *e.g.*,

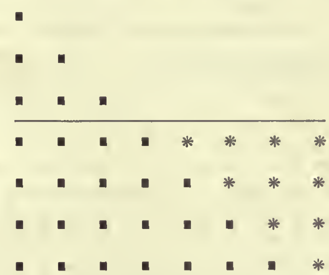
$$0+1=1,\ 1+2=3,\ 3+3=6,\ 6+4=10,\ 10+5=15,$$

and so on. It may be noticed also that any two consecutive triangular numbers are the most nearly equal parts into which a square of points can be divided by a line parallel to the diagonal. For example, in the square of 16 points, the two most nearly equal triangular parts are, $1+2+3=6$, and $1+2+3+4=10$. This is shown in the following diagram:—

Whether the square contains an even or an uneven number of points, the diagonal, which is in the middle, has to be given to one of the two parts, which therefore necessarily differ by the number of points it contains. In the square n^2, the two consecutive triangular numbers which form it are $\frac{1}{2}n(n-1)$ and $\frac{1}{2}n(n+1)$, differing, as they should, by n, the number of points in the diagonal. Viewing the same matter from a slightly different point of view, we see that any two consecutive triangular numbers always make a square, *e.g.*,

$$1+3=4,\ \ 3+6=9,\ \ 6+10=16,\ \ \&c.$$

It is interesting to exhibit by means of a diagram the manner in which the rectangle representing the product ab is derived from the three triangular numbers corresponding to $a-1$, b, $a-1-b$. As an example, the mode of formation of the product 8×4 is shown below, the triangular number corresponding to 7 being represented by dots and the triangular number corresponding to 4 by stars:—



The dots above the line form the triangular number corresponding to $7-4=3$.[1]

It is not suggested that the method just described by means of triangular numbers is comparable to that of quarter squares. It is certainly better to double the extent of the table and have but two entries. Still, it is interesting to note how readily a table of triangular numbers extending only to 10^n is available for the performance of multiplications of two n-figure numbers. So far as we know, only one extended table of triangular numbers has ever been published. This table, which gives the value of $\frac{1}{2}n(n+1)$ from $n=1$ to $n=20{,}000$, was published at the Hague, by E. de Joncourt, in 1762, under the title "De Natura et Præclaro Usu Simplicissimæ Speciei Numerorum Trigonalium." The book is a small and handsomely printed volume of 267 pages, 224 of which are occupied by the table.

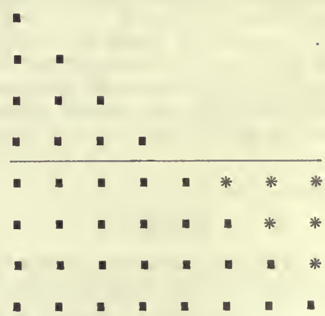
In tabulating quarter squares, the fraction $\frac{1}{4}$ which occurs when the square is uneven is omitted. If we denote by $\mathrm{qsq}\,n$ the tabulated quarter square of n, we have, therefore—

$$\mathrm{qsq}\,(2n) \quad = n^2,$$
$$\mathrm{qsq}\,(2n+1) = n^2 + n.$$

A table of quarter squares may be formed by adding to zero the numbers 1, 1, 2, 2, 3, 3, ... *e.g.* $0+1=1$, $1+1=2$, $2+2=4$, $4+2=6$, $6+3=9$, $9+3=12$, and so on. Its construction, therefore, is

[1] It is interesting to compare the two formulæ which involve half squares and triangular numbers respectively. In the former case we tabulate a discontinuous function, and in the use of the formula a unit has sometimes to be arbitrarily added. In the latter case we tabulate a continuous function, and the formula always holds good (the larger of the arguments being always reduced by unity). One formula depends on squares, n^2; the other on factorials of the second order, $n(n-1)$.

[1] We might of course also perform the multiplication thus:—



corresponding to the formula

$$ab = \mathrm{T}(a) + \mathrm{T}(b-1) - \mathrm{T}(a-b).$$

But if unity is subtracted from the smaller, instead of from the larger, number, slightly higher numbers are involved in the process.

very similar to that of a table of triangular numbers, the only difference being that the added numbers 1, 2, 3, ... are each twice repeated. We may also regard the tabulated quarter squares as defined by this rule: The quarter square of n is equal, if n be even, to the sum of all the uneven numbers less than n, and, if n be uneven, to the sum of all the even numbers less than n. For evidently the series $1 + 3 + 5 + \ldots\ldots + (2n - 1) = n^2$, and the series $2 + 4 + 6 + \ldots\ldots + 2n = n^2 + n$.

By means of this definition of a quarter square we may exhibit the method of quarter squares diagrammatically as follows.

Taking as examples the products 8×3 and 7×4, we have

$$\text{qsq } 11 - \text{qsq } 5 = 8 \times 3,$$

which may be represented by—

and

$$\text{qsq } 11 - \text{qsq } 3 = 7 \times 4,$$

which may be represented by—

The number of points in the extreme left-hand column of the difference of the quarter squares is always equal to the smaller of the numbers to be multiplied. If this number is uneven, there will be one middle line containing a number of points equal to the greater of the two numbers; the points in excess of this number are to be transferred from the line below the middle one to the line next above it, the excess from two lines below is to be transferred to make up the deficiency two lines above, and so on. If the smaller number is even, as in the second diagram, there are two middle lines differing from each other by two points; one point from the lower of these lines is to be transferred to the upper, three points from the line below the lower middle line to the line above the upper middle line, and so on.

It will be noticed that the tabulated quarter squares are, as it were, a species of triangular number in which the succeeding lines of points differ by two, instead of by one, as in ordinary triangular numbers (*i.e.* viewing the matter arithmetically, the quarter squares are derived alternately from the series $1 + 3 + 5 + \ldots$ and $2 + 4 + 6 + \ldots$, and the triangular numbers from the series $1 + 2 + 3 + \ldots$). It is the fact of the lines differing by two which enables us in all cases to adjust the points in the difference of two quarter squares so as to form a rectangle in the manner indicated above.

J. W. L. GLAISHER.

NOTES.

THE American Philosophical Society at Philadelphia is about to celebrate the centennial anniversary of the first occupation of its present hall. The celebration will be held on November 21. The Hon. Frederick Fraley, the President of the Society, will deliver an address in the afternoon of that day, and in the evening a banquet will be given at the Bellevue. The Society was founded in 1743 "for promoting useful knowledge."

ON November 16, the Naturwissenschaftlicher Verein of Bremen will celebrate the twenty-fifth anniversary of its foundation by an evening gathering and a banquet.

THE International Medical Congress will meet next year in Berlin, from August 4 to 10. Inquiries by intending visitors should be addressed to the General Secretary, Dr. Lassar, Karl Strasse, Berlin. The Congress will be divided into eighteen Sections, and the official languages will be German, English, and French.

THE Congress of the International Geodesic Association was opened in Paris, at the Foreign Office, on October 3. M. Spuller welcomed the delegates, who represented Austria, Belgium, Denmark, Spain, France, Greece, Hamburg, Hesse-Darmstadt, Italy, Holland, Prussia, Roumania, Servia, and Switzerland. M. Faye presided.

THE Ethnographic Congress, which held meetings of its various Sections every day last week in Paris, brought its proceedings to a close on Monday afternoon in one of the large halls of the College of France. It was decided that the Congress should hold its next meeting at Bucharest in the autumn of 1890.

THE next annual meeting of the Mineralogical Society will be held in the apartments of the Geological Society, Burlington House, London, on Tuesday, November 5, at 8 p.m.

THE Committee of the Sunday Lecture Society have decided that twenty-one lectures shall be given, during the winter, in St. George's Hall, Langham Place, on Sunday afternoons at 4 p.m., as in former years. The first lecture, on "The Origin and Uses of the Colours of Animals," with oxy-hydrogen lantern illustrations, will be delivered by Dr. Alfred Russel Wallace on October 20. This will be followed by lectures by Mr. John M. Robertson, Mr. Arthur Nicols, Mr. Chas. Cassal, Dr. Andrew Wilson, Prof. Percy Frankland, and Sir R. S. Ball.

ON Monday afternoon, about a quarter to 2 o'clock, a shock of earthquake was felt in Cornwall. It was accompanied by a loud underground noise like thunder, and was felt distinctly at Doubleborough, Boscastle, and Camelford. The earthquake is said to have been severe enough to shake houses, but no harm was done either to person or property.

THE death is announced from Georgetown, British Guiana, of Mr. E. E. H. Francis, Professor of Chemistry in Queen's College, Georgetown, and Analytical Chemist to the Government, at the early age of thirty-nine. Mr. Francis entered the service of British Guiana in 1875, having formerly been Professor of Chemistry and official analytical chemist in Trinidad. The two posts now vacant in Georgetown are said to be worth more than £700 per annum. Mr. Francis was a member of various learned Societies in this country.

AT the recent meeting of the Iron and Steel Institute, Mr. Frederick Siemens made some remarks during the discussion of Sir Lowthian Bell's paper on gaseous fuel, of which we gave an abstract last week. We draw attention to these remarks on account of the important influence Mr. Siemens's experiments and inventions have had on the application of gas for the heating of furnaces. Mr. Samson Fox had stated that he did not propose to use water gas alone for furnace purposes, but mixed with producer gas or other carburetted gas. Mr. Siemens said that a gas would thus be produced similar to that formed in the Siemens gas producer, which he had applied for a considerable time to furnace purposes. He had lately been experimenting with various gases for furnace use, and had come to the conclusion to divide gases generally into two classes, luminous and non-luminous. The latter, the class to which water gas belonged, could be advantageously used for heating by contact; as, for instance, in incandescent gas-lamps, for heating up refractory material to the temperature of incandescence, as the flame struck upon the material which had to give the light. But it would never do to heat high-temperature furnaces with a non-luminous gas, because it radiated very little light or heat, and, as he had proved some years ago, large furnaces must be heated by radiation to work economically and efficiently. Although it was proposed to mix water gas and producer gas, he thought that this would not be very easily effected, the one being supplied at a pressure, and the other without pressure. He had no doubt, however, that, if so mixed, they could be advantageously employed.

THE Report of the Manchester Technical School, presented at the annual meeting of the life members last week, is a very satisfactory document, and as a record of the year's work it is highly encouraging to all who are interested in the extension of technical instruction. The number of students has increased during the year from 2371 to 3328, and the amount paid in students' fees from £2970 to £3711, and the financial position is otherwise hopeful. The details of the work carried on in the school and in the recently-established spinning and weaving department, afford abundant evidence that the Council take a very comprehensive view of the sphere of technical education. The opening of this new department was the most important extension made during last year, and though at present the number of day students enrolled is small, there can be no doubt that, as the advantages it offers become better known, it will be more and more resorted to by those who wish to gain practical instruction in the chief textile industries in combination with the study of the scientific laws which regulate them. A considerable number of students are already attending the evening classes in the department. The Report refers to the proposal to establish a technical school in connection with the Whitworth Institute, and the prospects are considered promising by the Council. The negotiations between the Council and the Governors of the new institution will probably result in the foundation of a technical college on the scale, and with all the appliances, of the best schools of the kind in Germany and Switzerland. The growth of the school during the past six years is well shown in the following short table:—

Year ending July 31.	Individual students.	Tickets issued.	Fees. £ s. d.
1884	1429	2046	1259 12 5
1885	1995	2783	2010 10 5
1886	2299	3091	2241 11 8
1887	2529	3406	2931 10 4
1888	2871	3918	2970 1 8
1889	3328	4383	3711 15 0

THE grotto lately discovered near the caves of Adelsberg was said to be superior to these famous caverns. According to the Burgomaster of Adelsberg, who has written on the subject to the Vienna Correspondent of the *Times*, this is a mistake. The new grotto, he says, is very far from equalling the Adelsberg caves. It is a little more than a kilometre in length, and is believed to be a continuation of the Adelsberg caves. Its en-entrance is half an hour's walk from the latter, between the villages of Gressotak and Zagon. It is rich in stalactites, but most of these have the appearance of being covered with white chalk.

THE Boston Society of Natural History is at present much interested in a scheme for the establishment of natural history gardens in that city, and it has authorized its Council to proceed with the work as soon as the sum of 200,000 dollars shall have been raised for the purpose. Mr. A. Hyatt, Curator of the Society's Museum, is sanguine enough to write, in his latest Annual Report, that "it is perfectly feasible to establish a series of natural history gardens which shall co-operate with the Museum and other public work of the Society, and to form, perhaps, the most effective apparatus for public culture in natural history that has ever been planned before for any city in the world."

LAST week we noticed (p. 549) the work done, under the supervision of Prof. Giglioli, at the stations established in Italy for ornithological observations. Similar stations were created in Saxony, in accordance with the decisions of the Ornithological Congress held at Vienna in 1884, and we have now received the fourth annual Report relating to the results achieved by the observers. The Report, which is accompanied by a map, is by Dr. A. B. Meyer and Dr. F. Helm, and presents a great mass of information, clearly arranged. The first Report, issued in 1885, contained the facts noted in Saxony by 43 observers, at 35 stations, regarding 180 species of birds. In the present Report there is a record of what 122 observers at 111 stations have to tell about 213 species of birds.

A FULL report of the Apple and Pear Conference held at Chiswick from October 16–20, 1888, is presented in the tenth volume to the Journal of the Royal Horticultural Society. The report opens with the address delivered by the President, Sir Trevor Lawrence, after which come the following papers: apples for profit, by Mr. GeorgeBunyard; fruit culture for profit in the open air, by Mr. W. Paul; dessert pears, by Mr. W. Wildsmith; on pruning, by Mr. Shirley Hibberd; canker in fruit trees, by Mr. Edmund Tonks; canker, its cause and cure, by Mr. James Douglas; enemies of the apple and pear, by Mr. J. Fraser; apples for Sussex, by Mr. J. Cheal; orchards in the West Midlands, by Mr. W. Coleman; apples and pears for Scotland, by Mr. Malcolm Dunn; cultivation in Jersey, by Mr. C. B. Saunders; production and distribution, by Mr. F. J. Baillie; compensation for orchard planting, by Mr. W. F. Bear; the railway difficulty, by Mr. D. Tallerman. The volume includes statistical and other information, compiled by Mr. A. F. Barron, as to the cultivation of apples in Great Britain and Ireland; and a descriptive catalogue, also by Mr. Barron, of apples exhibited in 1883 and 1888.

A SECOND edition of Prof. Lloyd Morgan's "Animal Biology" (Rivingtons) has been issued. The author has revised the text, substituted in several cases improved woodcuts, and added a brief classification of the types, and a glossary.

THE Royal Geographical Society has issued the sixth edition of the well-known "Hints to Travellers," edited for the Society by Mr. Douglas W. Freshfield and Captain W. J. L. Wharton, R.N. The work has been revised and enlarged.

M. A. VAYSSIÈRE has just completed the publication of his "Atlas d'Anatomie comparée des Invertébrés," in 60 quarto plates. This atlas, accompanied by concise and clear explanations, has been received with much favour in the zoological laboratories.

M. R. BLONDEL has published a pamphlet of 150 pages, with plates, on the odorous properties of the rose, and the methods used in industry for the extraction of its perfume.

MR. WILLIAM JORDAN has issued a pamphlet entitled "Instructions to Inventors as to obtaining Letters Patent and registering Trade Marks and Designs." Reference is made to the latest patent laws of Great Britain, our colonies, and foreign countries.

MR. R. H. PORTER has sent us his October catalogue of new and secondhand books. It includes many works of scientific interest.

PROF. G. POUCHET, Director of the Laboratory of Concarneau, has published, in a large quarto volume of eighty-one pages, with plates, an account of experiments made by him under the auspices of the Municipal Council of Paris, on the currents of the North Atlantic. The work deals more particularly with the Gulf Stream, and with the details of the experiments made on board the *Hirondelle* with the assistance of the Prince of Monaco, but also takes into consideration the results of investigators from the earliest times. The experiments refute the idea that the French coast is warmed by the Gulf Stream; M. Pouchet states that they show clearly that, at least in summer, no surface-current reaches France from the south-west, but that, on the contrary, there is a current from the west and north-west.

THE following details about the Tomsk University have been published. The buildings constitute the finest edifice in the town, and are situated in the middle of a magnificent park. When the staff is complete there will be twenty-five Chairs—thirteen ordinary, eleven extraordinary, and one for orthodox theology. There will also be librarians, teachers of music, and surgeons and assistant-surgeons. There are already seventy-two students, who pay about 12 or 13 roubles a month for lodging, books, and attendance, and it is expected that this number will be largely increased before the end of the year.

THE Pilot Chart of the North Atlantic Ocean for the month of September shows that the most important storm during the month of August was one first reported about San Domingo on the 19th, whence it moved north-westward over the Bahamas and afterwards recurved and followed the course of the Gulf Stream. During the first half of the month the pressure along the Atlantic States was persistently high, and the tracks of all storms from the continent lay well to the northward of this area of high barometer, moving mostly beyond the region of observation. No storm can be traced all the way from the American continent to the British Isles, although several originated in mid-ocean and moved in an east-north-east direction. A severe tornado was reported off Cienfuegos, Cuba, on August 4. Ice was reported in great quantities about the Straits of Belle Isle, but very little off the Grand Banks.

METEOROLOGICAL science will be much enriched by the recent contributions of the Danish observers in Greenland during 1882-83 ("Expédition Danoise," vol. ii., part 2, Copenhagen, 1889). The principal station was at Godthaab, on the west coast of Greenland, in latitude about 64°, where the observations were made under the direction of M. Adam Paulsen. A large series of observations of temperature was made and the results are given in tables, as well as represented by curves. The temperature was taken every hour during twelve months, and the mean temperatures at each hour for each month are given in the tables. As might be expected, the greatest variation occurs in August—namely, from + 3°·5 C. at 3 a.m. to + 7°·2 at 2 p.m. The minimum variation is in February, from − 15°·4 to − 15°·7. During the summer months the maximum occurs about 1 p.m., and in winter about 2 p.m. Similar results are recorded for the stations at Reykjavik, in lat. 64° and Stykkisholm, in lat. 65°. The maximum monthly mean temperature occurs in July, and the minimum in February. Observations were also made of the direction, force, and velocity of the wind, form and direction of clouds, temperature of the soil, &c., full details of which are given in the report. An appendix contains the results of various meteorological observations in the Kara Sea in 1882-83, and at Nanortalik and D'Angmagsalik. Observations of auroræ at the two latter stations and at Godthaab also form part of the appendix. It is greatly to be regretted that the spectroscope was not employed in the auroral observations.

THE additions to the Zoological Society's Gardens during the past week include a Mealy Amazon (*Chrysotis farinosa*) from South America, presented by the Hon. and Rev. F. G. Dutton; two Cape Crowned Cranes (*Balearica chrysopelargus*) from South Africa, presented by the Hon. Mrs. Barker; seven Common Slowworms (*Anguis fragilis*), British, presented by Miss Alice Leonora Selly; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Mr. J. Watkins; a Long-nosed Crocodile (*Crocodilus cataphractus*) from West Africa, presented by Mr. John R. Holmes; a Royal Python (*Python regius*) from West Africa, deposited; four Common Rheas (*Rhea americana*) from Holland, purchased.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *OCTOBER* 13–19.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on October 13

Sun rises, 6h. 23m.; souths, 11h. 46m. 11·5s.; daily decrease of southing, 14·0s.; sets, 17h. 10m.: right asc. on meridian, 13h. 15·1m.; decl. 7° 57′ S. Sidereal Time at Sunset, 18b. 40m.

Moon (at Last Quarter October 17, 1h.) rises, 19h. 7m.*; souths, 2h. 57m.; sets, 11h. 0m.: right asc. on meridian, 4h. 24·4m.; decl. 19° 11′ N.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	7 2 ...	12 4 ...	17 6 ...	13 32·8 ...	12 4 S.
Venus.....	3 25 ...	9 56 ...	16 27 ...	11 24·3 ...	5 19 N.
Mars......	2 45 ...	9 29 ...	16 13 ...	10 57·6 ...	8 5 N.
Jupiter....	12 47 ...	16 39 ...	20 31 ...	18 9·0 ...	23 30 S.
Saturn....	1 36 ...	8 44 ...	15 52 ...	10 12·6 ...	12 27 N.
Uranus...	6 32 ...	11 54 ...	17 16 ...	13 23·1 ...	8 8 S.
Neptune..	18 54*...	2 43 ..	10 32 ..	4 10·3 ...	19 21 N.

* Indicates that the rising is that of the preceding evening.

Oct.	h.	
16 ...	0 ...	Mercury in inferior conjunction with the Sun.
16 ...	13 ...	Venus at least distance from the Sun.

Variable Stars.

Star.	R.A.	Decl.		
	h. m.	° ′		h. m.
U Cephei	0 52·5 ...	81 17 N. ...	Oct. 15,	2 45 *m*
λ Tauri...	3 54·5 ...	12 11 N. ...	,, 16,	21 36 *m*
ζ Geminorum ...	6 57·5 ...	20 44 N. ...	,, 13,	23 0 *M*
			,, 19,	2 0 *m*
U Coronæ	15 13·7 ...	32 3 N. ...	,, 17,	23 5 *m*
β Lyræ...	18 46·0 ...	33 14 N. ...	,, 16,	22 30 *M*
U Aquilæ	19 23·4 ...	7 16 S. ...	,, 19,	19 0 *M*
η Aquilæ	19 46·8 ...	0 43 N. ...	,, 13,	22 0 *M*
T Vulpeculæ ...	20 46·8 ...	27 1 N. ...	,, 19,	19 0 *M*
δ Cephei	22 25·1 ...	57 51 N. ...	,, 16,	21 0 *m*
S Aquarii	22 51·2 ...	20 56 S. ...	,, 14,	*M*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near γ Andromedæ ...	26 ...	43 N. ...	Slow; faint.
,, ξ Ceti	31 ...	9 N. ...	Slow; trained.
,, ν Arietis	41 ...	20 N. ...	Swift.
,, κ Cephei	307 ...	77 N. ...	Slow; faint.

THE LIFE-WORK OF A CHEMIST.[1]

IN asking myself what subject I could bring before you on the present occasion, I thought I could not do better than point out by one example what a chemist may do for mankind. And in choosing this theme for my discourse I found myself in no want of material, for amongst the various aspects of scientific activity there is surely none which, whether in its most recondite forms or in those most easily understood, have done more to benefit humanity than those which have their origin in my own special study of chemistry. I desired to show what one chemist may accomplish, a man devoted heart and soul to the investigation of Nature, a type of the ideal man of science—whose example

[1] An Address delivered to the members of the Birmingham and Midland Institute, in the Town Hall, Birmingham, on October 7, 1889, by Sir Henry E. Roscoe, M.P., D.C.L., LL.D., F.R.S., President.

may stimulate even the feeblest amongst us to walk in his footsteps if only for a short distance, whose life is a consistent endeavour to seek after truth if haply he may find it, whose watchwords are simplicity, faithfulness, and industry, and whose sole ambition is to succeed in widening the pathway of knowledge so that following generations of wayfarers may find their journeys lightened and their dangers lessened.

Such men are not uncommon amongst the ranks of distinguished chemists. I might have chosen as an example the life and labours of your sometime townsman, Joseph Priestley, had not this theme been already treated by Prof. Huxley, in a manner I cannot approach, on the occasion of the inauguration of the statue which stands hard by. To-day, however, I will select another name, that of a man still living, the great French chemist—Pasteur.

As a chemist Pasteur began life, as a chemist he is ending it. For although, as I shall hope to point out, his most important researches have entered upon fields hitherto tilled, with but scanty success, by the biologist, yet in his hands, by the application of chemical methods, they have yielded a most bountiful harvest of new facts of essential service to the well-being and progress of the human race.

And after all the first and obvious endeavour of every cultivator of science ought to be to render service of this kind. For although it is foolish and shortsighted to decry the pursuit of any form of scientific study because it may be as yet far removed from practical application to the wants of man, and although such studies may be of great value as an incentive to intellectual activity, yet the statement is so evident as to almost amount to a truism, that discoveries which give us the power of rescuing a population from starvation, or which tend to diminish the ills that flesh, whether of man or beast, is heir to, must deservedly attract more attention and create a more general interest than others having so far no direct bearing on the welfare of the race.

"There is no greater charm," says Pasteur himself, "for the investigator than to make new discoveries, but his pleasure is more than doubled when he sees that they find direct application in practical life." To make discoveries capable of such an application has been the good fortune—by which I mean the just reward—of Pasteur. How he made them is the lesson which I desire this evening to teach. I wish to show that these discoveries, culminating as the latest and perhaps the most remarkable of all, in that of a cure for the dreaded and most fearful of all fearful maladies, hydrophobia, have not been, in the words of Priestley, "lucky haphazardings," but the outcome of patient and long-continued investigation. This latest result is, as I shall prove to you, not an isolated case of a happy chance, but simply the last link in a long chain of discoveries, each one of which has followed the other in logical sequence, each one bound to the other by ties which exhibit the life-work of the discoverer as one consequent whole. In order, however, to understand the end we must begin at the beginning, and ask ourselves what was the nature of the training of hand, eye, and brain which enabled Pasteur to wrest from Nature secret processes of disease the discovery of which had hitherto baffled all the efforts of biologists. What was the power by virtue of which he succeeded when all others had failed, how was he able to trace the causes and point out remedies for the hitherto unaccountable changes and sicknesses which beer and wine undergo? What means did he adopt to cure the fatal silkworm disease, the existence of which in the south of France in one year cost that country more than one hundred millions of francs? Or how did he arrive at a method for exterminating a plague known as fowl cholera, or that of the deadly cattle disease, anthrax, or splenic fever, which has killed millions of cattle, and is the fatal woolsorters' disease in man? And last but not least how did he gain an insight into the working of that most mysterious of all poisons, the virus of hydrophobia?

To do more than point out the spirit which has guided Pasteur in all his work, and to give an idea of the nature of that work in a few examples, I cannot attempt in the time at my disposal. Of the magnitude and far-reaching character of that work we may form a notion, when we remember that it is to Pasteur that we owe the foundation of the science of bacteriology, a science treating of the ways and means of those minute organisms called microbes, upon whose behaviour the very life, not only of the animal, but perhaps also of the vegetable, world depends—a science which bids fair to revolutionize both the theory and practice of medicine, a science which has already, in the hands of Sir Joseph Lister, given rise to a new and beneficent application in the discovery of antiseptic surgery

The whole secret of Pasteur's success may be summed up in a few words. It consisted in the application of the exact methods of physical and chemical research to problems which had hitherto been attacked by other less precise and less systematic methods. His early researches were of a purely chemical nature. It is now nearly forty years ago since he published his first investigation. But this pointed out the character of the man, and indicated the lines upon which all his subsequent work was laid.

Of all the marvellous and far-reaching discoveries of modern chemistry, perhaps the most interesting and important is that of the existence of compounds which, whilst possessing an identical composition—that is, made up of the same elements in the same proportions—are absolutely different substances judged of by their properties. The first instance made known to us of such isomeric bodies, as they are termed by the chemist, was that pointed out by the great Swedish chemist Berzelius. He showed that the tartaric acid of wine-lees possesses precisely the same composition as a rare acid having quite different properties and occasionally found in the tartar deposited from wine grown in certain districts in the Vosges. Berzelius simply noted this singular fact, and did not attempt to explain it. Later on, Biot observed that not only do these two acids differ in their chemical behaviour, but likewise in their physical properties, inasmuch as the one (the common acid) possessed the power of deviating the plane of a polarized ray of light to the right, whereas the rare acid has no such rotatory power. It was reserved, however, for Pasteur to give the explanation of this singular and at that time unique phenomenon, for he proved that the optically inactive acid is made up of two compounds, each possessing the same composition, but differing in optical properties. The one turned out to be the ordinary dextro-rotatory tartaric acid; the other a new acid which rotates the plane of polarization to the left to an equal degree. As indicating the germ of his subsequent researches, it is interesting here to note that Pasteur proved that these two acids can be separated from one another by a process of fermentation, started by a mere trace of a special form of mould. The common acid is thus first decomposed, so that if the process be carried on for a certain time only the rarer lævo-rotatory acid remains.

Investigations on the connection between crystalline form, chemical composition, and optical properties, occupied Pasteur for the next seven years, and their results—which seem simple enough when viewed from the vantage-ground of accomplished fact—were attainable solely by dint of self-sacrificing labours such as only perhaps those who have themselves walked in these enticing and yet often bewildering paths can fully appreciate, and by attention to minute detail as well as to broad principles to an extent which none can surpass and few can equal. A knowledge of the action of the mould in the changes it effects on tartaric acid led Pasteur to investigate that *bête noire* of chemists, the process of fermentation. The researches thus inaugurated in 1857 not only threw a new and vivid light on these most complicated of chemical changes, and pointed the way to scientific improvements in brewing and wine-making of the greatest possible value, but were the stepping-stones to those higher generalizations which lie at the foundation of the science of bacteriology, carrying in their train the revolutions in modern medicine and surgery to which I have referred.

The history of the various theories from early times until our own day which have been proposed to account for the fact of the change of sugar into alcohol, or that of alcohol into vinegar, under certain conditions, a fact known to the oldest and even the most uncivilized of races, is one of the most interesting chapters in the whole range of chemical literature, but, however enticing, is one into which I cannot now enter. Suffice it here to say that it was Pasteur who brought light out of darkness by explaining conflicting facts and by overturning false hypotheses. And this was done by careful experiment, and by bringing to bear on the subject an intelligence trained in exact methods and in unerring observation, coupled with the employment of the microscope and the other aids of modern research.

What now did Pasteur accomplish? In the first place he proved that the changes occurring in each of the various processes of fermentation are due to the presence and growth of a minute organism called the ferment. Exclude all traces of these ferments, and no change occurs. Brewers' wort thus preserved remains for years unaltered. Milk and other complex liquids do not turn sour even on exposure to pure air, provided these infinitely small organisms are excluded. But introduce even the smallest trace of these microscopic beings, and the peculiar changes which they alone can bring about at once begin. A few cells of the yeast plant set up the vinous fermentation in a sugar solution. This is clearly stated by Pasteur as follows:—"My decided opinion," he says, "on the nature of alcoholic fermentation is the following. The chemical act of fermentation is essentially a correlative phenomenon of a vital act beginning and ending with it. I think that there is never any alcoholic fermentation without there being at the same time organization, development, multiplication of globules, or the continued consecutive life of globules already formed."

Add on a needle's point a trace of the peculiar growth which accompanies the acetous fermentation, and the sound beer or wine in a short time becomes vinegar. Place ever so small a quantity of the organism of the lactic fermentation in your sweet milk, which may have been preserved fresh for years in absence of such organisms, and your milk turns sour. But still more, the organism (yeast) which brings about the alcoholic fermentation will not give rise to the acetous, and *vice versâ*, so that each peculiar chemical change is brought about by the vital action of a peculiar organism. In its absence the change cannot occur; in its presence only that change can take place.

Here again we may ask, as Pasteur did, Why does beer or wine become sour when exposed to ordinary air? And the answer to this question was given by him in no uncertain tone in one of the most remarkable and most important of modern experimental researches. Milk and beer which have become sour on standing in the air contain living micro-organisms which did not exist in the original sound fluids. Where did these organisms originate? Are they or their germs contained in the air, or are these minute beings formed by a process of spontaneous generation from material not endowed with life?

A controversy as to the truth or falsity of the theory of spontaneous generation was waged with spirit on both sides, but in the end Pasteur came off victorious, for by a series of the most delicate and convincing of experiments he proved the existence of micro-organic forms and their spores—or seeds—in the air, and showed that whilst unpurified air was capable of setting up fermentative changes of various kinds, the same air freed from germs could not give rise to these changes. Keep away the special germ which is the incentive to the pathological change, and that change cannot occur. In the interior of the grape, in the healthy blood, no such organisms, no such germs exist; puncture the grape or wound the animal body, and the germs floating in the air settle on the grape-juice or on the wounded tissue, and the processes of change, whether fermentative or putrefactive, set in with all their attendant symptoms. But crush the grape or wound the animal under conditions which either preclude the presence or destroy the life of the floating germ, and again no such change occurs; the grape-juice remains sweet, the wound clean.

I have said that every peculiar fermentative change is accompanied by the presence of a special ferment. This most important conclusion has only been arrived at as the result of careful experimental inquiry. How was this effected? By the artificial cultivation of these organisms. Just as the botanist or gardener picks out from a multitude of wild plants the special one which he wishes to propagate, and planting it in ground favourable to its growth, obtains fresh crops of the special plant he has chosen, so the bacteriologist can by a careful process of selection obtain what is termed a pure cultivation of any desired organism. Having obtained such a pure cultivation, the next step is to ascertain what are the distinctive properties of that special organism; what characteristic changes does it bring about in material suitable for its growth. This having been determined, and a foundation for the science having thus been laid, it is not difficult to apply these principles to practice, and the first application made by Pasteur was to the study of the diseases of beer and wine.

In September 1871, Pasteur visited one of the large London breweries, in which the use of the microscope was then unknown. A single glance at the condition of the yeast instantly told its tale, and enabled him to explain to the brewers the cause of the serious state of things by which frequently as much as 20 per cent. of their product was returned on their hands as unsaleable—this being that this yeast contained foreign or unhealthy organisms. And just as pure yeast is the cause of the necessary conversion of wort into beer, so these strange forms which differ morphologically from yeast, and whose presence can therefore be distinctly ascertained, are the cause of acidity, ropiness, turbidity, and other diseases which render the beer undrinkable. It is no exaggeration to say that, whereas before Pasteur's researches the microscope was practically unknown in the brewhouse, it has now become as common as the thermometer or the saccharimeter, and by its help and by the interpretations we can place upon its revelations through Pasteur's teaching, yeast—of all brewers' materials the least open to rough and ready practical discernment—becomes easy of valuation as to its purity or impurity, its vigour or weakness, and, therefore, its behaviour during fermentation. Thus, while in former days the most costly materials were ever liable to be ruined by disease organisms unconsciously introduced into them with the yeast, at the present day the possibilities of any such vast pecuniary disasters become easily avertable.

Of all industries, brewing is perhaps the one which demands the most stringent care in regard to complete and absolute cleanliness. The brewers' materials, products, and by-products, are so putrescible, there is always so vast an abundance of disease-organisms in the brewery air, that the minutest amounts of these waste products lying about in vessels or pipes transform these places into perfect nests for the propagation of these micro-organisms, whence, transferred into the brewings, they inevitably ruin them, however carefully and scientifically prepared in other respects. Without the microscope, any breach of discipline in the way of the supreme cleanliness necessary is impossible of detection; with it we can track down the micro-organisms to their source, whether it be in uncleanly plant, in impurity of materials, or in carelessness of manipulation.

Among the more direct applications of Pasteur's researches, the so-called Pasteurization of beer claims a place. Pasteur showed that temperatures well below the boiling-point sufficed for destroying the disease organisms in alcoholic fluids, and, based on these results, enormous quantities of low-fermentation beers are annually submitted to these temperatures, and thus escape the changes otherwise incident to the micro-organisms which have succumbed to the treatment. This process is, however, for several intricate reasons, not suited for English beers, but if we cannot keep our beers by submitting them to high temperatures, we can foretell to a nicety how they will keep by artificially forcing on those changes which would occur more slowly during storage. The application of a suitable temperature, the exclusion of outside contamination, a microscopic examination of the "forced" beer, and the knowledge which we owe to Pasteur of what the microscopic aspect means, suffice to make each brewing foretell its own future history, and thus suffice to avert the otherwise inevitable risks incident to the storage and export of beer, the stability of which is unknown.

Brewing has thus become a series of precise and definite operations, capable of control at every point. Instead of depending—as it had to depend—on intuition and experience handed down in secrecy from father to son, it now depends upon care, forethought, and the soundness of the brewer's scientific training. This change in the nature of the brewer's operations, and in the persons who govern them, is primarily due to Pasteur. Other men have done much to carry on his work, but it is to his example of ceaseless patience, and to his example of freely publishing to the world all the results of his work, that the brewers of all countries are indebted for the connection of each phenomenon with a controllable cause, and for thus emancipating their industry from empiricism and quackery.

Much the same story has to be told about Pasteur's investigation of wine and its diseases. As with the brewer, so with the wine-grower Pasteur has pointed out the causes of his troubles, and, the causes having been ascertained, the remedies soon followed, and the practical value of these researches to the trade of France and other wine-producing countries has been enormous.

The next labour of our scientific Hercules was of a different kind, but of a no less interesting or important character. The south of France is a great silk-producing district. In 1853 the value of the raw silk was represented by a sum of some five millions sterling, and up to that date the revenue from this source had been greatly augmenting. Suddenly this tide of prosperity turned, a terrible plague broke out amongst the silkworms, and in 1865 so general had the disease become that the total production of French silk did not reach one million, and the consequent poverty and suffering endured in these provinces became appalling. Every conceivable means was tried to overcome the disease, but all in vain. The population and the Government of France—for the evil was a national one—were at their wits' end, and a complete collapse of one of the most important French industries seemed inevitable. Under these circumstances the great chemist Dumas, who was born at Alais, in the centre of one of the districts most seriously affected, urged his friend Pasteur to undertake an investigation of the subject. Pasteur, who at this time had never seen a silkworm, naturally felt diffident about attempting so difficult a task, but at last, at Dumas' renewed entreaty, he consented, and in June 1865 betook himself to the south for the purpose of studying the disease on the spot. His previous training here again stood him in good stead, and in September 1865 he was able to communicate to the Academy of Sciences results of observation and experiment which, striking at the root of the evil, pointed the way to the means of securing immunity from the dreaded plague. This paper was freely criticized. Here, it was said, was a chemist who, quitting his proper sphere, had the hardihood to lay down rules for the guidance of the physician and biologist in fields specially their own. Why should his proposals be more successful than all the other nostrums which had already so egregiously failed?

In order to appreciate the difficulties which met Pasteur in this inquiry, and to understand how wonderfully he overcame them, I must very shortly describe the nature of this disease, which is termed *pébrine*, from the black spots which cover the silkworm. It declares itself by the stunted and unequal growth of the worms, by their torpidity, and by their fastidiousness as to food, and by their premature death.

Before Pasteur went to Alais the presence of certain microscopic corpuscles had been noticed in the blood and in all the tissues of the diseased caterpillar, and even in the eggs from which such worms were hatched. These micro-organisms often fill the whole of the silk organs of the insect, which in a healthy condition contain the clear viscous liquid from which the silk is made. Such worms are of course valueless. Still this knowledge did not suffice, for eggs apparently healthy gave rise to stricken worms incapable of producing silk, whilst again other worms distinctly diseased yielded normal cocoons. These difficulties, which had proved too much for previous observers, were fully explained by Pasteur. "The germs of these organisms," said he, "which are so minute, may be present in the egg and even in the young worms, and yet baffle the most careful search. They develop with the growth of the worm, and in the chrysalis they are more easily seen. The moth derived from a diseased worm invariably contains these corpuscles, and is incapable of breeding healthy progeny."

This moth-test is the one adopted by Pasteur, and it is an infallible one. If the female moth is stricken, then her eggs—even though they show no visible sign of disease—will produce sick worms. If in the moth no micrococci are seen, then her immediate progeny at any rate will be sound and free from inherited taint, and will always produce the normal quantity of silk. But this is not all. Pasteur found that healthy worms can be readily infected by contact with diseased ones, or through germs contained in the dust of the rooms in which the worms are fed. Worms thus infected, but free from inherited taint, can, however, as stated, spin normal cocoons, but—and this is the important point—the moths which such chrysalides yield invariably produce diseased eggs. This explains the anomalies previously noticed. The silkworms which die without spinning are those in which the disease is hereditary, viz. those born from a diseased mother. Worms from sound eggs which contract the disease during their life-time always spin their silk, but they give rise to a stricken moth, the worms from which do not reach maturity and furnish no silk.

As I have said, these results were but coldly received. It was hard to make those engaged in rearing the worms believe in the efficacy of the proposed cure. Then, seeing this state of things, Pasteur determined to take upon himself the *rôle* of a prophet. Having in 1866 carefully examined a considerable number of the moths which had laid eggs intended for incubation, he wrote down a prediction of what would happen in the following year with respect to the worms hatched from these eggs. In due course, after the worms from a mixed batch of healthy and unhealthy eggs had spun, the sealed letter was opened and read, and the prediction compared with the actual result, when it was found that in twelve out of fourteen cases there was absolute conformity between the prediction and the observation, for twelve hatchings were predicted to turn out diseased, and this proved to be the case. Now all these "educations" were believed to be healthy by the cultivators, but Pasteur foretold that they would turn out to be diseased by the application of the moth-test in the previous year. The other parcels of eggs were pronounced by Pasteur to be sound, because they were laid by healthy moths containing none of the micrococci, and both these yielded a healthy crop. So successful a prophecy could not but gain the belief of the most obtuse of cultivators, and we are not surprised to learn that Pasteur's test was soon generally applied, and that the consequence has been a return of prosperity to districts in which thousands of homes had been desolated by a terrible scourge.

I must now ask you to accompany me to another and a new field of Pasteur's labours, which, perhaps more than his others, claims your sympathy and will enlist your admiration, because they have opened out to us the confident hope of at least obtaining an insight into some of the hidden causes and therefore to the possible prevention of disease.

In the first place, I must recall to your remembrance that most infectious diseases seldom if ever recur, and that even a slight attack renders the subject of it proof against a second one. Hence inoculation from a mild case of small-pox was for a time practiced, but this too often brought about a serious if not fatal attack of the malady, and the step taken by Jenner of vaccinating, that is of replacing for the serious disease a slight one which nevertheless is sufficient protection against small-pox infection, was one of the highest importance. But Jenner's great discovery has up to recent years remained an isolated one, for it led to no general method for the preventive treatment of other maladies, nor had any explanation been offered of its mode of action. It is to Pasteur that science is indebted for the generalization of Jenner's method, and for an explanation which bids fair to render possible the preventive treatment of many—if not of all—infectious diseases. It was his experience, based upon his researches on fermentation, that led to a knowledge of the nature of the poison of such diseases, and showed the possibility of so attenuating or weakening the virus as to furnish a general method of protective or preventive inoculation.

I have already pointed out how a pure cultivation of a microbe can be effected. Just as the production of pure alcohol depends on the presence of the pure yeast, so special diseases are dependent on the presence of certain definite organisms which can be artificially cultivated, and which give rise to the special malady. Can we now by any system of artificial cultivation so modify or weaken the virus of a given microbe as to render it possible to inoculate a modified virus which, whilst it is without danger to life, is still capable of acting as a preventive to further attack? This is the question which Pasteur set himself to solve, nor was the task by any means an apparently hopeless one. He had not only the case of Jennerian vaccination before him, but also the well-known modifications which cultivation can bring about in plants. The first instance in which Pasteur succeeded in effecting this weakening of the poison was in that of a fatal disease to which poultry in France are very liable, called chicken cholera. Like many other maladies, this is caused by the presence of a micro-organism found in the blood and tissues of the stricken fowl. One drop of this blood brought under the skin of a healthy chicken kills it, and the same microbe is found throughout its body. And if a pure culture of these microbes be made, that culture—even after a series of generations—is as deadly a poison as the original blood. Now comes the discovery. If these cultures be kept at a suitable temperature for some weeks exposed to pure air, and the poisonous properties tested from time to time, the poison is found gradually to become less powerful, so that after the lapse of two months a dose which had formerly proved fatal now does not disturb in the slightest the apparent health of the fowl. But now let us inoculate a chicken with this weakened virus. It suffers a slight illness, but soon recovers. Next let us give it a dose of the undiluted poison, and, as a control, let us try the action of the same on an unprotected bird. What is the result? Why, that the first chicken remains unaffected, whilst the second bird dies. The inoculation has rendered it exempt from the disease, and this has been proved by Pasteur to be true in thousands of cases, so that, whereas the death-rate in certain districts amongst fowls before the adoption of Pasteur's inoculation method was 10 per cent., after its general adoption it has diminished to less than 1 per cent.

We can scarcely value too highly this discovery, for it proves that the poisonous nature of the microbe is not unalterable, but that it can be artificially modified and reduced, and thus an explanation is given of the fact that in an epidemic the virus may either be preserved or become exhausted according to the conditions to which it is subjected. We have here to do with a case similar to that of Jenner's vaccine, except that here the relation between the weak and the strong poison has become known to us, whilst in Jenner's case it has lain concealed. This, then, is the first triumph of experimental inquiry into the cause and prevention of microbic disease, and this method of attenuation is of great importance, because, as we shall see, it is not confined to the case of chicken cholera, but is applicable to other diseases.

And next I will speak of one which is a fatal scourge to cattle, and is not unfrequently transmitted to man. It is called anthrax, splenic fever, or woolsorters' disease. This plague, which has proved fatal to millions of cattle, is also due to a microbe, which can be cultivated like the rest, and the virus of which can also be weakened or attenuated by a distinct treatment which I will not here further specify. Now, what is the effect of inoculating cattle or sheep with this weakened poison? Does it act as a preventive? That the answer is in the affirmative was proved by Pasteur by a convincing experiment. Five-and-twenty sheep, chosen promiscuously out of a flock of fifty, were thus inoculated with the weak virus, then after a time all the fifty were treated with the strong poison. The first half remained healthy, all the others died of anthrax. Since the discovery of this method, no fewer than 1,700,000 sheep and about 90,000 oxen have thus been inoculated, and last year 269,599 sheep and 34,464 oxen were treated. The mortality which, before the introduction of the preventive treatment, was in the case of sheep 10 per cent., was, after the adoption of the method, reduced to less than 1 per cent. So that now the farmers in the stricken districts have all adopted the process, and agricultural insurance societies make the preventive inoculation a *sine quâ non* for insuring cattle in those districts. This is, however, not the end of this part of my story, for Pasteur can not only thus render the anthrax poison harmless, but he has taught us how to bring the highly virulent poison back again from the harmless form. This may go to explain the varying strength of an attack of infectious disease, one case being severe and another but slight, due to the weakening or otherwise of the virus of the active microbe.

Last, but not least, I must refer to the most remarkable of all Pasteur's researches, that on rabies and hydrophobia. Previous to the year 1880, when Pasteur began his study of this disease, next to nothing was known about its nature. It was invested with the mysterious horror which often accompanies the working of secret poisons, and the horror was rendered greater owing to the fact that the development of the poison brought in by the bite or by the lick of a mad dog might be deferred for months, and that, if after that length of time the symptoms once make their appearance, a painful death was inevitable. We knew indeed that the virus was contained in the dog's saliva, but experiments made upon the inoculation of the saliva had led to no definite results, and we were entirely in the dark as to the action of the poison until Pasteur's investigation. To begin with, he came to the conclusion that the disease was one localized in the nerve-centres, and to the nerve-centres he therefore looked as the seat of the virus or of the microbe. And he proved by experiment that this is the case, for a portion of the matter of the spinal column of a rabid dog, when injected into a healthy one, causes rabies with a much greater degree of certainty and rapidity than does the injection of the saliva. Here, then, we have one step in advance. The disease is one of the nerve-centres, and, therefore, it only exhibits itself when the nerve-centres are attacked. And this goes to explain the varying times of incubation which the attack exhibits. The virus has to travel up the spinal cord before the symptoms can manifest themselves, and the length of time taken over that journey depends on many circumstances. If this be so, the period of incubation must be lessened if the virus is at once introduced into the nerve-centres. This was also proved to be the case, for dogs inoculated under the *dura mater* invariably became rabid within a period rarely exceeding eighteen days.

Next came the question, Can this virus be weakened, as has been proved possible with the former poisons? The difficulty in this case was greater, inasmuch as all attempts to isolate or to cultivate the special microbe of rabies outside the animal body had failed. But Pasteur's energy and foresight overcame this difficulty, and a method was discovered by which this terrible poison can so far be weakened as to lose its virulent character, but yet remain potent enough, like the cases already quoted, to act as a preventive; and dogs which had thus been inoculated were proved to be so perfectly protected, that they might be bitten with impunity by mad dogs, or inoculated harmlessly with the most powerful rabic virus.

But yet another step. Would the preventive action of the weakened virus hold good when it is inoculated even after the bite? If so, it might be thus possible to save the lives of persons bitten by mad dogs. Well, experiment has also proved this to be true, for a number of dogs were bitten by mad ones, or were inoculated under the sk with rabic virus; of these some were subjected to the preventive cure and others not thus treated. Of the first or protected series not one became mad, of the other, or unprotected dogs, a large number died with all the characteristic symptoms of the disease. But it was one thing to thus experiment upon dogs, and quite another thing, as you may well imagine, to subject human beings to so novel and perhaps dangerous a treatment. Nevertheless, Pasteur was bold enough to take this necessary step, and by so doing has earned the gratitude of the human race.

In front of the Pasteur Institute in Paris stands a statue worked with consummate skill in bronze. It represents a French shepherd boy engaged in a death struggle with a mad dog which had been worrying his sheep. With his bare hands, and with no weapon save his wooden *sabot*, the boy was successful in the combat. He killed the dog, but was horribly bitten in the fight. The group represents no mythical struggle; the actual event took place in October 1885; and this boy, Jupille, was the second person to undergo the anti-rabic treatment, which proved perfectly successful, for he remained perfectly healthy, and his heroic deed and its consequences have become historic. "*C'est le premier pas qui coute*," and as soon as the first man had been successfully treated, others similarly situated gladly availed themselves of Pasteur's generous offer to treat them gratuitously. And as soon as this cure became generally known, crowds of persons of all ages, stations, and countries, all bitten by rabid animals, visited every day Pasteur's laboratory in the Rue d'Ulm, which, from being one in which quiet scientific researches were carried on, came to resemble the out-patient department of a great hospital. There I saw the French peasant, the Russian *moujik* (suffering from the terrible bites of rabid wolves), the swarthy Arab, the English policeman, with women too and children of every age, in all perhaps a hundred patients. All were there undergoing the careful and kindly treatment, which was to insure them against a horrible death. Such a sight will not be easily forgotten. By degrees this wonderful cure for so deadly a disease attracted the attention of men of science throughout the civilized world. The French nation raised a monument to the discoverer better than any statue, in the shape of the "Pasteur Institute"—an institution devoted to carrying out in practice this anti-rabic treatment, with laboratories and every other convenience for extending by research our knowledge of the preventive treatment of infectious disease.

For, be it remembered, we are only at the beginning of these things, and what has been done is only an inkling of what is to come. Since 1885, twenty anti-rabic institutions have been established in various parts of the world, including Naples, Palermo, Odessa, St. Petersburg, Constantinople, Rio Janeiro, Buenos Ayres, and Havannah.

We in England have also taken our share, though a small one, in this work. In 1885 I moved in the House of Commons for a Committee to investigate and report on Pasteur's anti-rabic method of treatment. This Committee consisted of trusted and well-known English men of science and physicians—Sir James Paget, Sir Joseph Lister, Drs. Burdon Sanderson, Lauder Brunton, Quain, Fleming, and myself, with Prof. Victor Horsley as secretary. We examined the whole subject, investigated the details of a number of cases, repeated Pasteur's experiments on animals, discussed the published statistics, and arrived unanimously at the opinion that Pasteur was justified in his conclusions, and that his anti-rabic treatment had conferred a great and lasting benefit on mankind. Since then His Royal Highness the Prince of Wales, who always takes a vivid interest in questions affecting the well-being of the people, has visited the Pasteur Institute, and has expressed himself strongly in favour of a movement, started by the present Lord Mayor of London, for showing to Pasteur, by a substantial grant to his Institute, our gratitude for what he has done to relieve upwards of 250 of our countrymen who have undergone treatment at his hands, and likewise to enable poor persons who have been bitten, to undertake the journey to Paris, and the sojourn there necessary for their treatment. This lasts about a fortnight, it is nearly painless, and no single case of illness, much less of hydrophobia—due to the preventive treatment—has occurred amongst the 7000 persons who have so far undergone the cure.

Now let me put before you the answer to the question, Is this treatment a real cure? For this has been doubted by persons, some of whom will I fear still doubt or profess to doubt, and still abuse Pasteur whatever is said or done! From all that can be learnt about the matter, it appears pretty certain that about from fifteen to twenty persons out of every hundred bitten by mad dogs or cats, and not treated by Pasteur's method, develop the disease, for I need scarcely add that all other methods of treatment have proved fallacious; but bites on the face are much more dangerous, the proportion of fatal cases reaching 80 per cent. Now of 2164 persons treated in the Pasteur Institute, from November 1885 to January 1887, only thirty-two died, showing a mortality of 1·4 per cent. instead of fifteen to twenty, and amongst these upwards of 2000 persons, 214 had been bitten on the face, a class of wounds in which, as I have said, when untreated, the mortality is very high; so that the reduction in the death-rate seems more remarkable, especially when we learn that in all these cases the animal inflicting the wound had been proved to be rabid. The same thing occurs even in a more marked degree in 1887 and 1888. In 1887, 1778 cases were treated, with a mortality of 1·3 per cent., whilst last year 1626 cases were treated, with a mortality of 1·16 per cent.[1]

Statistics of the anti-rabic treatment in other countries show similar results, proving beyond a doubt that the death-rate from hydrophobia is greatly reduced. Indeed, it may truly be said that in no case of dangerous disease, treated either by medicine or surgery, is a cure so probable. Moreover, in spite of assertions to the contrary, no proof can be given that in any single case did death arise from the treatment itself. And as showing the safety of the inoculation, I may add that all Pasteur's assistants and laboratory workers have undergone the treatment, and no case of hydrophobia has occurred amongst them.

You are no doubt aware that Pasteur's anti-rabic treatment has been strongly opposed by certain persons, some of whom have not scrupled to descend to personal abuse of a virulent character of those who in any way encouraged or supported Pasteur's views, and all of whom persistently deny that anything good has come or can come from investigations of the kind. Such persons we need neither fear nor hate. Their opposition is as powerless to arrest the march of science as was King Canute's order to stop the rising tide. Only let us rest upon the sure basis of exactly ascertained fact, and we may safely defy alike the vapourings of the sentimentalist and the wrath of the opponent of scientific progress. But opposition of a much fairer character has likewise to be met, and it has with propriety been asked—How comes it that Pasteur is not uniformly successful? Why, if what you tell us is true, do any deaths at all follow the anti-rabic treatment? The answer is not far to seek. In the first place, just as it is not every vaccination which protects against small-pox, so Pasteur's vaccination against rabies occasionally fails. Then, again, Pasteur's treatment is really a race between a strong and an attenuated virus. In cases in which the bite occurs near a nerve-centre, the fatal malady may outstrip the treatment in this race between life and death. If the weakened virus can act in time, it means life. If the strong virus acts first, prevention comes too late—it means death. So that the treatment is not doubtful in all cases, but only doubtful in those which are under well-known unfavourable conditions. This, it seems to me, is a complete reply to those who ignorantly fancy that, because Pasteur's treatment has not cured every case, it must be unreliable and worthless.

One word more. I have said that Pasteur is still—as he has always been—a chemist. How does this fit in with the fact that his recent researches seem to be entirely of a biological character? This is true. They seem, but they really are not. Let me in a few sentences explain what I mean. You know that yeast produces a peculiar chemical substance—alcohol. How it does so we cannot yet explain, but the fact remains. Gradually, through Pasteur's researches, we are coming to understand that this is not an isolated case, but that the growth of every micro-organism is productive of some special chemical substance, and that the true pathogenic virus—or the poison causing the disease—is not the microbe itself, but the chemical compound which its growth creates. Here once more "to the solid ground of nature trusts the man that builds for aye," and it is only by experiment that these things can be learnt.

[1] For further details, see Dr. Ruffer, *Brit. Med. Journ.*, Sept. 21, 1889.

Let me illustrate this by the most recent and perhaps the most striking example we know of. The disease of diphtheria is accompanied by a peculiar microbe, which, however, only grows outside, as it were, of the body, but death often takes place with frightful rapidity. This takes place not by any action of the microbe itself, but by simple poisoning due to the products of the growing organism, which penetrate into the system, although the microbe does not. This diphtheritic *Bacillus* can be cultivated, and the chemical poison which it produces can be completely separated by filtration from the microbe itself, just as alcohol can be separated from the yeast granules. If this be done, and one drop of this pellucid liquid given to an animal, that animal dies with all the well-known symptoms of the disease. This, and similar experiments made with the microbes of other diseases, lead to the conclusion that in infectious maladies the cause of death is poisoning by a distinct chemical compound, the microbe being not only the means of spreading the infection, but also the manufacturer of the poison. But more than this, it has lately been proved that a small dose of these soluble chemical poisons confers immunity. If the poison be administered in such a manner as to avoid speedy poisoning, but so as gradually to accustom the animal to its presence, the creature becomes not only refractory to toxic doses of the poison, but also even to the microbe itself. So that instead of introducing the micro-organism itself into the body, it may now only be necessary to vaccinate with a chemical substance which in large doses brings about the disease, but in small ones confers immunity from it, reminding one of Hahnemann's dictum of "Similia similibus curantur."

Here then we are once more on chemical ground. True, on ground which is full of unexplained wonders, which, however, depend on laws we are at least in part acquainted with, so that we may in good heart undertake their investigation, and look forward to the time when knowledge will take the place of wonder.

In conclusion, I feel that some sort of apology is needed in thus bringing a rather serious piece of business before you on this occasion. Still I hope for your forgiveness, as my motive has been to explain to you as clearly as I could the life-work of a chemist who has in my opinion conferred benefits as yet untold and perhaps unexampled on mankind, and I may be allowed to close my discourse with the noble words of our hero spoken at the opening of the Pasteur Institute in the presence of the President of the French Republic:—

"Two adverse laws seem to me now in contest. One law of blood and death, opening out each day new modes of destruction, forces nations to be always ready for the battlefield. The other a law of peace, of work, of safety, whose only study is to deliver man from the calamities which beset him.

"The one seeks only violent conquests. The other only the relief of humanity. The one places a single life above all victories. The other sacrifices the lives of hundreds of thousands to the ambition of a single individual. The law of which we are the instruments, strives even through the carnage to cure the bloody wounds caused by this law of war. Treatment by our antiseptic methods may preserve thousands of soldiers.

"Which of these two laws will prevail over the other? God only knows. But of this we may be sure, that science in obeying this law of humanity will always labour to enlarge the frontiers of life."

THE PHYSICAL PAPERS AT THE BRITISH ASSOCIATION.

PROF. A. W. RÜCKER, F.R.S., read a paper on cometic nebulæ. Prof. Lockyer has suggested that comet-like nebulæ may be caused by the passage of a very dense swarm through a stream of meteorites, the relative velocity of the two being very considerable. The author has, therefore, attempted to calculate the increase in the number of collisions which takes place in the rear of an attracting mass which passes through a swarm of meteorites so sparsely scattered through space that the main effects of the attraction are produced in a distance which is small compared with the length of the mean free path. Assuming, with Clausius, that the particles have equal velocities equally distributed in all directions, and which are small compared with the relative velocity of approach, the collisions will be most numerous within a cone the apex of which is the attracting body or nucleus, and which contains the lines which are parallel to the relative velocities of the individual meteorites and the nucleus when at an infinite distance apart. The collisions will increase enormously when the nebulæ come nearer the sun, and will take place about every second at points, in round numbers, 100 miles apart.

Prof. C. Piazzi Smyth, late Astronomer-Royal for Scotland, read a paper entitled "Re-examination of the Spectra of Twenty-three Gas-vacuum, End-on Tubes, after six to ten years of existence and use." This inquiry began in an attempt to ascertain, by refined mensurations, whether there was any sensible difference of spectral place for hydrogen lines, when they appeared adventitiously and scantily in tubes of other and very different gases, or in tubes of nothing but pure and abundant hydrogen by original intention. But, after having obtained a negative in every case, the inquirer became more taken up with the *changes* that had occurred in certain of the tubes subsequent to 1880, when he published upon them in the Transactions of the Royal Society of Edinburgh. Thus, a chlorine tube, of which it was printed in 1880 that it was then still showing its chlorine lines, though fainter, after two years' use; while carbon bands and hydrogen lines had begun to appear; yet now, in 1889, it has nothing but hydrogen lines, and in great brilliance, to show. Again, an iodine tube which had a comparatively large quantity of solid iodine granules introduced into, and sealed up in, its interior eleven years ago; and showed then a splendid spectrum of 148 measured iodine lines, extending discontinously from red to violet, and had nothing else, *save* three very faint puny images of the three principal lines of hydrogen—this tube, in 1889, has not a single iodine line now left; but its spectrum, which is brighter than ever, is composed of nothing but hydrogen lines, so that the once solid iodine granules would seem to be partly changed into hydrogen, and partly deposited on the inside of the tube as yellow haze, besides leaving a trifle of loose dust. The author also mentions with much satisfaction that a London maker, Mr. Charles Casella, transcended all others by supplying him with one tube of CO, two of N, and two of O, which have, through six years of existence and work, shown their respective spectra without a trace of hydrogen.

Lord Rayleigh, Sec. R.S., in a paper on the tones of bells, said that observations were made on a considerable number of bells of the usual church pattern. The pitch of the various tones, usually five for each bell, was fixed by comparison with a harmonium and with the aid of resonators. The nominal pitch of the bells appears to depend on the *highest* of the tones recorded. From a musical point of view it would seem that all the bells are far removed from perfection; while the differences of relative pitch in the various cases recorded indicates that it may be possible to effect an improvement even to the extent of bringing all the five tones into harmonious relations. The quality of the sound is, however, very difficult to estimate, and even the imperfect octaves, of which several examples occur, give much less of a dissonant effect than might have been expected.

Captain Abney, F.R.S., read a paper on the quantity of deposit of silver produced by the development on a photographic plate in terms of the intensity of light acting. The author concludes from his experiments that the deposit of silver made by different intensities of light varies directly as the intensity of light acting—this, of course, within such limits that reversal of the image is not commenced, and that the film is not at any part exhausted of the silver salt which can be reduced.

Lord Rayleigh, Sec. R.S., read a paper on pin-hole photography. It was shown, in the *Philosophical Magazine* for 1880, that a simple aperture was as effective as the best possible lens in forming an image, provided only that the focal length (f) was sufficiently great. Conversely, if f be given, the aperture may be made so small that the use of a lens will give no advantage; but if the focal length was such as was usually afforded by a camera, the admissible aperture, being very much less than that of the pupil of the eye, is insufficient for reasonably good definition. In some recent experiments the focal length was about 9 feet, and the aperture $\frac{1}{10}$ inch. The specimens exhibited were taken upon gelatine plates, and represented a weathercock seen against the sky. The amount of detail was not materially less than that observable by direct vision in the case of ordinary eyes, but modern plates are so sensitive that there would be no difficulty in working with an aperture equal to that of the pupil, other than that incurred in providing a focal length of 66 feet, with the necessary exclusion of foreign light.

Prof. O. J. Lodge, F.R.S., and Mr. R. T. Glazebrook, F.R.S., read a paper on the determination of v by means of electric oscillations. The authors have recently made a determination of v, using the oscillatory discharge of a condenser. The period of the discharge, which passed between two terminals connected through a circuit of measured self-induction to a condenser of known capacity, was determined by forming an image of the spark on the edge of a rapidly revolving circular photographic plate, the rate of revolution being accurately ascertained.

Prof. A. W. Rücker, F.R.S., read a paper on the instruments used in the recent magnetic survey of France. A magnetic survey of France has recently been completed by M. Mourceaux, who has determined the magnetic elements at some seventy stations. Prof. Rücker exhibited a set of instruments recently made under the supervision of M. Moureaux for the Science Museum at South Kensington. The point aimed at in their construction was to secure accuracy combined with dimensions and weight much less than those of the Kew pattern instruments. The main points in the construction are (1) that the needles used are much smaller than those used in the Kew pattern instruments; (2) the end of the declination needle forms a concave mirror, and a reading is taken when the image of a linear mark formed by the mirror is in the prolongation of another line which is exactly opposite to the first on a thin piece of metal; (3) the geographical meridian is determined by a theodolite, which forms part of the apparatus, instead of by using—as in the Kew—a plane mirror to reflect the image of the sun into a horizontal telescope; (4) extremely fine silk threads are able to support the small magnets used; (5) in the dip circle the graduated arc rotates in its own plane about a horizontal axis, and a reading is taken when the end of the needle and its image, formed by a concave mirror attached to the graduated circle, coincide when viewed through a microscope.

Prof. J. A. Ewing, F.R.S., in a paper on the magnetic viscosity of iron, described experiments showing that in certain circumstances the process is gradual by which iron assumes magnetization after the imposition of magnetizing force. The experiments are given in detail in Proc. Roy. Soc., June 20, 1889.

Prof. Everett, F.R.S., read a paper on the relation between brachistochrones and ray-paths, in which he pointed out an application of well-known laws of optics to the comparison of the law of force for a free path with the law of force for a path of least time, the path itself being supposed given; and to the closely allied problems of deducing the form of the path of least time from the form of the free path when the law of force is given. Most of his results, he stated, have previously been obtained by means of the principle of least action, but the optical method will be available for many students who have not mastered that principle.

Prof. Cayley, F.R.S., addressed the Section on curves in space.

Prof. J. A. Ewing, F.R.S., read a paper on hysteresis in the relation of strain to stress. It is now well known that when an iron wire is subjected to the alternate application and removal of tensile stress, many times repeated, certain of its qualities which are affected by the changes of stress exhibit hysteresis with regard to the changes of stress. If the load is cyclically varied between definite limits, these qualities do not have the same values at corresponding intermediate points during the application and removal of load; there is hysteresis or lagging in the change of quality, and in some cases this appears to be of a static character—that is to say, independent of the time-rate of variation of stress. Conspicuous instances of this action are seen in the change of magnetic and thermo-electric qualities under change of stress, some of which have been described by the author in former papers. It is natural to look for an effect of the same kind in the extension and retraction which the wire undergoes. We should expect that, after the change of loads has been frequently repeated so that a cyclic *régime* is established, the wire will, for any value of load intermediate between the two extremes, be longer during unloading than during loading. Evidently, if such an effect exist, it must be small, as it is well known that the proportionality of strain to stress which is expressed by Hooke's law is at least approximately exact. Sir W. Thomson's experiments on the damping of torsional vibrators have long ago shown that an action of the kind spoken of occurs in quickly-performed cycles of torsional strain. But it does not appear to have been looked for in slow cycles of longitudinal pull. The author has, with the assistance of one of his students, Mr. D. Low, looked for the effect in question, and has found it, not only in iron, but in steel, brass, and copper wires. He has not yet examined other metals. The experiment consisted in observing, with much optical magnification, the extension of a very long piece of wire, directly loaded with lead weights. The wire was hung from a rigid support in a testing flue or recess, built in the wall of the laboratory, and extending up through four stories. At a distance of 806 cms. below the top a small clamp was fixed on the wire, and this formed the support of the back foot of a little tripod, the feet of which consisted of three needle points about an inch apart. The two front feet rested in a slot and hole in a fixed shelf which stood in front of the long wire. The tripod carried a plane mirror which became tilted forward or backward as the wire extended or retracted. Readings were taken by a telescope of the reflected scale of a levelling staff placed vertically at a distance of some 5 metres from the mirror. The staff was graduated to 1/100 of a foot, and it was easy to read by estimation to 1/1000 of a foot, which corresponded to 0·000000102 of the length of the wire. At first a fixed shelf was used to support the two front feet of the mirror, but the effects of temperature were found to be excessive, although the greatest care was taken to shield the wire from draughts; and the plan was resorted to of hanging the shelf from two adjacent wires of the same material, suspended from the same support as the wire which was to be stretched. In this form the arrangement for optical multiplication was nearly the same as one used by Mr. Bottomley in recent experiments on the extension of loaded wires by heat.

Prof. Henry Stroud, in a paper on the E.M.F. produced by an abrupt variation of temperature at the point of contact of two portions of the same metal, gave the results of experiments on the E.M.F. produced when two portions of the same metal are in contact, and one portion is *kept* at a high temperature and the other at a low temperature. The precautions necessary in the performance of such experiments are discussed in the paper, and the results obtained are given in the case of copper and iron. The E.M.F. established in the case of copper is from hot to cold across the junction, while in the case of iron it is from cold to hot, and of far greater magnitude. These experiments are being continued with a view to obtaining the relation between the E.M.F. and the difference of temperature.

Prof. McLeod, F.R.S., in a paper on the black-bulk thermometer *in vacuo*, concludes the black bulbs should be as small as possible, and very little of the stem blackened, and also that the case should be as thin as is consistent with strength.

Sir W. Thomson, F.R.S., communicated a paper, by Magnus Maclean and Makita Goto, on electrification of air by combustion. A series of experiments was made, under the instructions of Sir William Thomson, for the purpose of endeavouring to find: (1) the state of the air inside a room as regards electrification; (2) the relation between electrification of air within a building and the atmospheric potential in its neighbourhood outside; and (3) the causes which produce or change the electrification of any given mass of air. It was found that an inclosed mass of air is electrified negatively by the burning of a paraffin lamp, of coal gas, of sulphur, of magnesium, and of several other substances; and, on the other hand, the burning of charcoal electrified a room positively.

Prof. C. Michie Smith read some notes on atmospheric electricity and the use of Sir W. Thomson's portable electrometer. Recent observations fully confirm the author's previous conclusions that, with a dry west wind, the potential of the air for some distance above the ground is usually negative. This seems always to be associated with dusty air. In using the portable electrometer in hot moist climates, special precautions have to be taken in drying it. As much sulphuric acid must be used as the pumice can absorb, and the pumice should be dried at least once a fortnight. The charging-rod itself must be very carefully dried, and, after charging, should be lifted out with a piece of warm silk.

Mr. A. W. Clayden read a paper on dark flashes of lightning. The author exhibited a negative taken on June 6 last, which shows several reversed images of lightning-flashes. He described a series of experiments which he had carried out with the object of discovering whether the phenomenon could be imitated in the laboratory. The steps in the investigation were illustrated by a series of negatives showing photographs of electric sparks. The conclusions arrived at are, that photographic images of electric sparks can be reversed by the action of diffused light. Reversal is only produced when the exposure to diffused light is subsequent to (or possibly simultaneous with) exposure to the image of the spark. If the plate is first acted upon by diffused light, the sparks give a direct image unless the action has been considerable, in which case they seem to make no impression.

Prof. Cleveland Abbe, in a paper on the determination of the amount of rainfall, gave a *résumé* of the general results of investigations on this subject. The deficit in catch by a gauge due to the eddies of wind is shown, on general reasoning, to be proportional to the velocity of the wind and to the relative percentage of small and slowly-falling drops.

Prof. C. Piazzi Smyth, late Astronomer-Royal for Scotland, read a paper entitled "Hygrometry in the *Meteorological Journal*." After noting the superior value officially attached to determinations of the mean temperature by observations of self-registering thermometers, recording its maximum and minimum every twenty-four hours, the author inquires why the still more difficult problem of ascertaining the mean daily moisture of the atmosphere is thrown over to a different principle of observing, long since condemned for simple temperature. Believing that the want of good self-registering dry- and wet-bulb thermometers for the purpose was the chief obstacle, and having alighted on some recent makes of Sixe's thermometers with several very recommendable qualities, he invested two out of four of them with the peculiar fittings for wet-bulb hygrometers, after having made a table of index corrections for them all, as compared with standard thermometers. But as soon as hygrometric observations began, the depression of the wet, below the dry, bulb always came out at only two-thirds of what a standard but non-registering Glaisher arrangement gave out, for the horizontal form of Sixe, and no more than half for a vertical form. These differences of hygrometric statement, though rather puzzling for a time, were traced up to the wet bulbs of the Sixe's thermometers being in contact on one side with the scale-plate. For when that plate in the horizontal Sixe form was cut entirely away from the bulb, and a new vertical form of Sixe was made (*per* Mr. James Bryson, Edinburgh) with its long thin bulb wholly outside the rest of the instrument, the indications of all three varieties of wet-bulb hygrometers became practically the same; and hygrometry was relieved of the old drawback on its registrations of maximum and minimum quantities of moisture in every twenty-four hours.

Mr. F. T. Trouton read a paper on some experiments on radiation with Prof. Hertz's mirrors. These experiments were described in NATURE, vol. xxxix. p. 391, and vol. xl. p. 398. Certain of them were repeated by Mr. Trouton in the Physical Laboratory of the Durham College of Science.

Profs. A. W. Rücker, F.R.S., and T. E. Thorpe, F.R.S., read a paper, on the relation between the geological constitution and the magnetic state of the United Kingdom, before a joint meeting of Sections A and C. The authors have, during the last five summers, determined the magnetic elements at 200 stations, distributed over the whole of the United Kingdom, and have employed the results of their observations in a study of the disturbing magnetic forces in play in various districts. If all disturbing causes were removed, an observer travelling due west from London would find that the declination increased by about half a degree for each degree of longitude. In fact, the rate of increase, though equal on an average to this amount, is irregular. Between London and Windsor it is considerably larger, and between Windsor and Reading smaller than the mean. The forces which produce these abnormal variations depend upon the geological character of the district. Two principal theories have been proposed to account for these disturbances: (1) the theory of direct action of magnetic rocks; (2) the other explanation associates the deflection of the needle with disturbances of the earth currents of electricity produced by irregularities in the geological constitution of the country, and especially with geological faults. On the whole, the authors think that the theory of the direct action of magnetic rocks agrees best with the observed facts, and they have shown that the kingdom can be divided into a small number of magnetic districts in which the directions of the disturbing forces are evidently closely connected with the geological constitution.

In a paper on the passage of electricity through gases, Prof. Arthur Schuster, F.R.S., gave an acccount of his investigations during the last two years on the distribution of potential in the neighbourhood of the negative pole of discharge of electricity through rarefied gases. Knowing the rate of fall of potential, it can be determined whether there is any bodily electrification in any part of the negative glow. It was found that the kathode is surrounded by an atmosphere of positively electrified gaseous particles extending to the outer edge of the so-called dark space. According to the author's views, this atmosphere corresponds to the polarized layer adjoining the negative electrode in an electrolyte. The cause of the sudden difference in luminosity between the dark space and the negative glow has also been investigated, and it has been found that negative particles projected from the kathode pass unhindered through the dark space, while their velocity is quickly reduced in the glow proper, the translatory energy being thus changed into energy of vibration.

Prof. Oliver J. Lodge, F.R.S., read a paper on the failure of metal sheets to screen off the electrostatic effect of *moving* or *varying* charges. Experiments have been made on the screening effect of a very thin film of silver chemically deposited, the thickness of the deposit being different in the different experiments. The silver screens are only found to protect so long as they are opaque; they no longer do so when the deposit is so thin as to be transparent.

Prof. James Blyth described a new form of current-weigher. In the construction of balances for the measurement of electric currents, a greater or less difficulty has always been experienced in leading the current into the movable parts of the instrument without seriously interfering with its sensibility. Several methods have been adopted to overcome this difficulty. In some balances the current is led in by mercury cups; in others, flexible leads, made of thin wire spirals or thin metal strips, are employed; while, in the recent balances by Sir William Thomson, the difficulty has been overcome by means of his well-known ligature suspension. Some time ago it occurred to the author that still another form of balance might be employed for this purpose, and the present paper is a short description of one which he has made. The balance referred to is of the ordinary Roberval type, with the pivot connections all replaced by tightly-stretched torsion wires. It is constructed as follows:—On a flat base-board are placed two vertical uprights of wood or other insulating material, about 6 inches apart. Between these are stretched two parallel wires in the same vertical plane about 3 inches apart. To the middle points of these wires are soldered the two horizontal metal bars of the Roberval. These are about 9 inches long. Both horizontal bars terminate at each end either in forks or rings, placed in a horizontal plane, and wires are tightly stretched between the prongs of the forks, or across a diameter of the rings. To the middle points of these last wires are attached, also by soldering, the vertical bars of the balance, thus completing what takes the place of the ordinary jointed parallelogram of the Roberval. The vertical bars have metal terminals, insulated from each other, and carry the circular disks, on the rims of which the movable coils of wire are wound. The bars pass at right angles through the centres of the disks, and are fixed to them at their middle points. The middle coils, which are of exactly the same diameter as the movable ones, are supported from the base-board, and are placed so that one is about half an inch above one movable coil, while the other is as much below the other movable coil. From this it will be seen that, when the balance is in equilibrium, the fixed and movable coils are all horizontal, with a space of about half an inch between each pair. The stretched wires may be either of steel or phosphor-bronze, and before being finally soldered are placed under considerable tension. The current flows through the instrument thus:—Entering, say, by the upper wire connecting the fixed supports, it passes to the upper horizontal bar. There it splits into two, one half (supposing the resistances equal) passing to each end of the bar, and, by means of the corresponding fork-wires, passing through the movable coils. From the movable coils each half returns along the lower horizontal bar, and together pass out by the lower wire connecting the two main supports. From this the whole current passes first through the one fixed coil, and then through the other, and in such a direction as to produce a repulsion between each pair of coils. In the constructing, care is taken that the suspended coils are both made of equal weight, and that when the balance is in equilibrium no torsion is in any of the wires. Small scale-pans are attached to each vertical bar, and a bob for raising or lowering the centre of gravity of the whole is placed on a rod springing at right angles from the middle of one of the horizontal bars. The current strength is estimated by the weight needed to restore the balance to equilibrium when disturbed by the passage of the current. A sliding weight may also be used, as in a steelyard. It will be readily seen that, as in all forms of current-weigher, the weights are proportional to the square of the current strength.

Prof. S. P. Thompson described a phenomenon in the electro-chemical solution of metals—originally discovered by Planté—which occurs when a current is passed between two copper wires immersed in dilute sulphuric acid in a cell. The solution takes place in two stages, the metal first oxidizing, and then the oxide dissolving in the acid. This was projected on the screen, the audience being able to observe that the bubbles evolved when the current was turned on ceased as the current died down, choked by the formation of oxide, but almost immediately re-commenced when the oxide began to dissolve. The author has tried other metals and other acids—silver, zinc, and iron showing similar effects in sulphuric acid, but not in nitric, acetic, or hydrochloric acids.

Mr. J. Wilson Swan read a paper on chromic acid as a depolarizer in Bunsen's battery. When chromic acid became an article of commerce at a moderate price, it occurred to the author to see if he could not obtain a substitute for the nitric acid of the Bunsen battery. As the results of his experiments he finds that a solution, of the composition nitric acid 1 part, chromic acid 2 parts, sulphuric acid 5 parts, and water 5 parts, gives results equal to that obtained with nitric acid.

Prof. Perry, F.R.S., described a variable standard of self-induction. An instrument like that hitherto used as a variable standard by Prof. Ayrton and the author, was used by Prof. Hughes. It is a fixed coil of wire, inside which a movable coil is placed; the coils are in series one with another. When their planes are parallel there is either a minimum or a maximum co-efficient. When the movable coil is rotated so that its plane makes various angles with the plane of the fixed coil, a pointer shows on a scale the coefficient for that particular position.

In another paper on a hot twisted strip voltmeter, Prof. Perry described the behaviour of twisted strips subjected to axial pull. A small elongation is accompanied by a great rotation, so that these strips may be employed in measuring-instruments such as weighing-machines, aneroid barometers, testing-machines, &c. For the Ayrton and Perry voltmeter a double twisted strip of platinum silver with its ends insulated is initially in tension inside a tube or frame two-thirds brass and one-third iron, a pointer at the middle of the strip being visible above a dial and capable of a motion of nearly 360°. When the current passes the pointer rotates because of the heating of the strip. By continuous making and breaking of a large current through the strip during seventy-two hours all zero and other errors seem to be eliminated. The highest reading of the exhibited instrument was 2½ volts, so that it is particularly useful in accumulator-work. The author gave the law of transformers generally, and found that a small transformer on the base of the instrument converted it into a voltmeter of any range whatsoever for alternating currents, the readings being independent of the frequency of alternation. The author exhibited twisted strips of carbon made by Messrs. Woodhouse and Rawson, which he intends to use for voltmeters of higher range.

Mr. W. H. Preece, F.R.S., read a paper on the relative effects of steady and alternate currents on different conductors. Sir W. Thomson, at the Bath meeting of the British Association, stated that alternating currents entered a distance of only about 3 millimetres into the heart of a thick round copper conductor, when the frequency was 150. This "diffusion law," as he called it, is dependent on the coefficient of self-induction and on the frequency, *i.e.* on the number of complete alternations of positive and negative currents transmitted per second. As this law has a most important bearing on the commercial value of systems of distribution dependent on alternating currents, it becomes most desirable to study the question practically. The verification of this law is almost beyond the reach of experiment. It occurred to the author, however, that if conductors of different materials are taken, such as iron, copper, lead, and platinoid, of easily measurable lengths and of convenient sectional areas, and if measurable and variable currents, both alternating and direct, approximately similar to those used in practice, are transmitted through them, the question could be studied by observing any difference, if such existed, in the total expenditure of energy in the conductors under these different circumstances. The general conclusion to be drawn from the experiments is that practically no serious error has been made in the form of conductors so much used for alternating current systems, and that nothing cheaper or better has been devised than a simple stranded conductor coated with a suitable insulating coating. The experiments do not solve the question of the distribution of current density through the section of the conductor, but they do show that within the range of practice the total flow of energy is the same in copper conductors, whether it be urged by alternate or by steady currents.

Prof. G. Forbes, F.R.S., and Mr. W. H. Preece, F.R.S., in a paper on a new thermometric scale, suggest the joule as the thermal unit instead of the therm or the calorie. 4·2 joules will raise the temperature of 1 gramme of water at 4° one degree, hence to raise 1 gramme of water from freezing-point to boiling-point requires 420 joules; and it is suggested that the difference of temperature between freezing- and boiling-points should be represented by 420 units of temperature.

Mr. J. T. Bottomley, F.R.S., exhibited some large Leyden jars, broken during the testing of a large Wimshurst machine which was being constructed by Sir Archibald Campbell, Bart., of Blythswood. They were excellent examples of multiple fracture.

Prof. S. P. Thompson, in a paper on sparkless electro-magnets, discussed the various means of suppressing the sparks in the circuits of electro-magnets. The most effective means, he finds, is to surround the core of the magnet with a substantial shield of copper. The author illustrated his method by experiments before the Section.

Mr. W. W. Haldane Gee and Dr. Arthur Harden read a paper on stereometry. This communication relates to the methods used for the determination of the volumes of bodies to which the hydrostatic method is not applicable. The authors have devised a convenient form of instrument, first proposed by Say, and afterwards modified by Leslie, Kopp, Regnault, and Miller. They have also shown that the following method for ascertaining volumes is very generally applicable, and likely to be of considerable service in physico-chemical researches. The body whose volume is desired is inclosed within a vessel of known volume, and then carbon dioxide (or other dry soluble gas) is passed into it for some time. The gas is then displaced by dry air (or other gas), and the volume of the carbon dioxide driven out is ascertained *gravimetrically* by absorption in bulbs containing caustic potash solution. By first filling the vessel with dry air and then driving it out with carbon dioxide, the volume of the air, and hence that of the body, may also be ascertained *volumetrically*, but with less accuracy. The gravimetric method is especially applicable for accurately ascertaining the density of soluble gases. For this purpose it is far more convenient than the process of direct weighing as used by Regnault.

In a paper on the specific heat of caoutchouc, Mr. W. W. Haldane Gee and Mr. Hubert L. Terry described a number of determinations which had been made of the specific heat of Para india-rubber which had been masticated, hydraulically compressed, and then cut into sheets from 0·22 millimetre to 1·40 millimetre thick. The rubber was alternated with sheets of tin-foil, and heated for two hours in a steam-jacket at 100° C. A modification of Regnault's method of mixtures was employed to find the specific heat of the hot rubber. Owing to the non-conducting nature of the substance the time of the calorimeter attaining its maximum temperature is as long as ten minutes; hence it has been necessary to apply special formulæ for the correction due to cooling. Those proposed by Pfaundler, Pape, and Schuster have been used, and the results calculated in accordance with them. The mean of the best-conducted experiments gives for the Para rubber the number 0·486. The investigation is being extended to allied bodies, especially the different forms of vulcanized rubber and gutta-percha.

Mr. F. T. Trouton read a paper on the temporary thermo-currents in iron. If a portion of an iron wire connected up to a galvanometer be heated red hot, and the heated portion be caused to travel along the wire by moving the flame, a current is produced, which is due to the fact that when iron changes its molecular state at the temperature of recalescence this change does not take place at the same temperature on heating as on cooling, so that when a flame is moved along an iron wire so as to continuously heat it above the temperature of recalescence the junction of the altered with the unaltered metal in front is at a higher temperature than of the junction behind the flame.

Prof. Barrett read a paper on recalescence of iron.

THE CHEMICAL PAPERS AT THE BRITISH ASSOCIATION.

OWING, doubtless, to the numerous chemical industries of the district, many of the papers read in Section B at Newcastle were of special interest to the technical student.

The President's Address on "The Metallurgy of Iron" was followed by the Report of the Committee for Investigating the Influence of Silicon on the Properties of Steel. From the results of Mr. Hadfield's experiments, it appears that silicon by itself does not produce a steel that will harden by water-quenching. The brittleness noticed in ordinary so-called silicon steel is due, not to silicon alone, but to the combined presence of the two hardeners, silicon and carbon. Silicon, up to 6 per cent., does not destroy the malleability of iron, nor are the magnetic properties greatly affected by increasing percentages of silicon, as is the case with manganese steel.

The Committee for Establishing an International Standard for the Analysis of Iron and Steel reported that they had made good progress with the work, and hoped before long to have the necessary analyses completed.

Some curious experiments were described by Mr. J. W. Hogg, on the volatilisation of lead oxide and its action upon glass at low temperatures. If some writing is placed upon a glass plate or platinum-foil, using lead oxide as a pigment, if a polished plate of glass be placed over this as closely as possible and prevented from actual contact by suitable means, upon now heating up to scarcely visible redness, a distinct reverse of the design will appear upon the upper glass. The quantity of lead oxide which will produce this effect is not shown by the most delicate balance.

Photographers were interested in Prof. Liveing's account of a new developer, "Eikonogen," which appears to give greater detail than most of those now in use. The tone of the negative is also excellent. Eikonogen is the sodium salt of amido-β-naphthol-β-sulphonic acid.

Mr. C. T. Heycock and Mr. F. H. Neville read a paper on Raoult's method applied to alloys. Alloys of a number of metals with sodium and tin were studied. The "atomic fall" of the freezing-point for aluminium was about half that of most other metals—pointing to twice the present number as the atomic weight of aluminium. Antimony produces a rise in the freezing-point of the alloy, for some unexplained reason. Contrary to Raoult's so-called second law, it was found that the nature of the solvent is of influence; 1 atomic weight of metal in 100 atomic weights of sodium not giving the same fall as 1 in 100 of tin. The method would seem to give a means for correcting and verifying atomic weights; though it does not give much information as to the molecular weight. It was shown that, in accordance with Van 't Hoff's theories on the nature of solution, each metal produces its own lowering of the freezing-point in presence of others.

On the Friday morning, Prof. Dunstan read the Report on the present methods of teaching chemistry.

Prof. Bedson afterwards gave an interesting description of Dr. Netto's process, at work on the Tyne, for the manufacture of aluminium from cryolite. The cryolite is first fused with salt in a reverberatory furnace; then run out into converters in which sodium is gradually added—about five pounds at a time. Sodium fluoride and metallic aluminium are formed. The sodium is obtained by allowing molten caustic soda to flow gradually onto charcoal contained in a cast-iron retort heated to dull redness. The sodium carbonate formed in the reaction sinks to the bottom of the retort. The greater concentration of the caustic soda thus produced enables the temperature to be kept lower than in the Castner process.

An account was afterwards given, by Mr. J. H. I. Dagger, of the Cowles method for manufacturing aluminium alloys.

On Monday, numerous Reports of Committees were handed in, the most interesting being that read by Dr. Richardson on the action of light on the hydracids. Dr. Richardson has found that, if white light is allowed to act upon water in presence of oxygen, a considerable quantity of hydrogen peroxide is produced. This accounts for the fact mentioned in previous Reports, that a mixture of dry oxygen with dry hydrogen chloride, or bromide, is unaffected by light.

Dr. Richardson also exhibited and described a new self-registering actinometer, based on the fact, discovered by Budde, that chlorine expands in the actinic rays, contracting again in the dark.

Prof. H. B. Dixon gave an account of experiments made by himself and Mr. J. A. Harker, on the explosion of a mixture of hydrogen, chlorine, and oxygen. It was found, in contradiction to previous statements, that steam is produced by the explosion even when chlorine is in excess. It was noted that hydrogen and chlorine, when exploded alone, give a sensible contraction.

In another paper the same workers show that hydrogen and chlorine do not explode when dry, unless exposed to very intense light.

Dr. A. P. Laurie gave some results of his researches on artists' colours. He is comparing the recipes given in the manuscripts of the old masters with those in modern use.

A new ferment was described on Tuesday, in a paper by Prof. P. F. Frankland, Miss Grace F. Frankland, and Mr. J. J. Fox. From the products of its activity, ethyl alcohol and acetic acid, it is termed *Bacillus ethaceticus*. It will cause a solution of mannite to ferment, while dulcite is unaffected by it.

In his paper on the Constitution of the Aromatic Nucleus, Mr. S. A. Sworn gave preference to the octahedral formula of Thomsen. A further development of Thomsen's formula, he believes, affords a full explanation of the laws of para- and meta-substitution.

Dr. Isaac Ashe read a paper entitled "Dimidium: an Attempt to represent the Chemical Elements by Physical Forms." He put forward the view that the primordial basis is to be found in an element having half the combining weight of hydrogen. This hypothetical element is named dimidium. The relations of attraction and repulsion under the influence of polar force suggest a linear form for such a body. A series of vortex-rings, superposed one on the other, would yield a form elongated in one direction and limited in the other two. Having shown that the primordial element may have a bar-like form of definite length, the author proceeds to construct models of the different elements, conforming in each case to the combining weight, valency, crystalline form, &c.

SOCIETIES AND ACADEMIES.

Paris.

Academy of Sciences, September 30.—M. Des Cloizeaux, President, in the chair.—Presentation of the fourth sheet of the Bulletin of the International Committee for preparation of a map of the heavens; meeting of Committee at Paris Observatory, by M. E. Mouchez. Five other Observatories (Vienna, Catania, Mexico, Manilla, and the Vatican) have been added to the original sixteen. Each Observatory will have to take about 700 photographs in the zone alloted to it, and it is hoped to finish the work in three or four years. A central office for utilizing the results will be necessary.—Addition to the theory of thin weirs extending throughout the breadth of the bed of a water-course; calculation of variations in the contraction of the outflowing sheet at its lower face, by M. J. Boussinesq.—On the last communication of Halphen to the Academy, by M. F. Brioschi.—On the denomination of the industrial unit of work, by M. H. Resal. He advocates the unit of 100 kilogrammetres, to be called the *quintalmetre*.—On the application of high temperatures in observing the spectrum of hydrogen, by MM. L. Thomas and Ch. Trépied. The electric arc is found a sure and comparatively easy way of making hydrogen sufficiently luminous for spectroscopic observation, even with large dispersions; (four jets of the gas were made to converge conically towards an axis coinciding with that of the carbons).—On concatenation (*enchainement*) of the atomic weights of the elements, by M. Delauney. He shows that the atomic weights may be joined together by addition in each case of the square root of a whole number, which is variable, but always *harmonic* (not containing any other prime factors than 1, 2, 3, and 5).—Combinations of cupric oxide with amylaceous matters, sugars, and mannites; new reagents for proximate analysis, by M. Ch.-Er. Guignet. Solutions of cellulose, also dry starch, or inuline, give well-defined combinations with oxide of copper, when put in contact with its solution in ammonia. Some sugars (pure glucose from honey, galactose, &c.) quickly precipitate copper ammonio-sulphate (but not the oxide); and while inverted sugar does not precipitate the sulphate, a previous addition of glucose produces a deposit of the glucosic combination (which does not retain ammonia). Mannite and dulcite, &c., yield at once blue precipitates in an ammoniacal sulphate of copper solution, which reagent is useful with decoctions of vegetable matters, as most substances in these are not precipitated by it.—On the number and calibre of nerve-fibres in the common oculomotor nerve, in the new-born and in the adult cat, by M. H. Schiller. The number does not increase during life (or increases very little); average 2942 in the kitten, 3035 in the cat. The calibre is increased six or eight times.—On the preceding investigation, by M. Aug. Forel. Various researches point to the stability of the nervous elements during life, and this he regards as very important for explanation of the phenomena of memory.—On the vitality of trichinæ, by M. Paul Gibier. He submitted small pieces of fresh pork with numerous trichinæ (which were much more lively when brought out of their cysts into a water-heated vessel than those of the salt meat) to a temperature of 20° to 25° below zero, for about two hours, and found the animals, on reheating, as lively as before.—The innervation of the osphradium of mollusks, by M. Paul Pelseneer. Like the other sensorial organs of mollusks, the osphradium proves to be innervated by the cerebral ganglion.—On the *Spongeliomorpha Saportai*, a new Parisian species, by M. S. Menier.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

On the Causes, Treatment, and Cure of Stammering: A. G. Bernard (Churchill).—A Text-book of Physiology, 5th Edition, Part 2: M. Foster (Macmillan).—A Contribution to the Flora of Derbyshire: Rev. W. H. Painter (Bell).—Notes on the Pinks of Western Europe: F. N. Williams (West).—Watts' Dictionary of Chemistry, vol. ii.: M. M. P. Muir and H. F. Morley (Longmans).—The Microscope in the Brewery and Malthouse: C. G. Matthews and F. E. Lott (Bemrose).—An Epitome of the Synthetic Philosophy: F. H. Collins; Preface by H. Spencer (Williams and Norgate).—Watts' Manual of Chemistry, vol. i. 2nd edition: W. A. Tilden (Churchill)—Nature Stories, Myths, and Phantasies (Hamilton).—Prodromus of the Zoology of Victoria, Decade xviii.: F McCoy (Trübner).—Service Chemistry: V. B. Lewes (Whittingham).—Chemical Technology; vol. i. Fuel and its Applications: E. J. Mills and F. J. Rowan (Churchill).—The Cradle of the Aryans: G. H. Rendall (Macmillan).—Mount Vesuvius: J. L. Lobley (Roper and Drowley).—Thermodynamics of the Steam-Engine: C. H. Peabody (Macmillan)—A Manual of Forestry, vol. i. The Utility of Forests and Fundamental Principles of Sylviculture: W. Schlich (Bradbury).—Sixth Annual Report of the Bureau of Ethnology, 1884–85: J. W. Powell (Washington).—Hydrostatics for Beginners: F. W. Sanderson (Macmillan). Differential Equations: W. W. Johnson (Macmillan).—Manures and their Uses: A. B. Griffiths (Bell).—A Text-book of Physiology; vol. ii. Special Physiology: J. G. M'Kendrick (Glasgow, Maclehose)—Problems of the Future, and Essays: S. Laing (Chapman and Hall).—Geological Record for 1880–84. vol. ii.: Edited by Topley and Sherborn (Taylor and Francis).—The Brook and its Banks: Rev. J. G. Wood (Religious Tract Society).—Memoirs and Proceedings of the Manchester Literary and Philosophical Society, 4th series, vol. ii. (Manchester).—Notes Biographiques sur J. C. Houzeau: A. Lancaster (Bruxelles).—Notes on Indian Insect Pests, vol. i. No. 1 (Calcutta).—Das Australische Florenelement in Europe; Dr. C. Ettingshausen (Gray)—Onderhouden Trillingen van Gespannen Draden: H. J. Oosting (Helder De Boer).—Records of the Geological Survey of New South Wales, vol. i. Part 2 (Sydney, Potter).—Internationales Archiv für Ethnographie, Band ii. Heft 4 (Trübner).—Jahrbuch der k.k. Geologischen Reichsanstalt, Jahrg. 1889, xxxix. Band, 1 and 2 Heft (Wien, Hölder).—The Photographic Quarterly, No. 1 (Hazell).—Bulletin of the United States National Museum, No. 37: W. H. Dall (Washington).—Aus dem Archiv der Deutschen Seewarte, xi. Jahrg., 1888 (Hamburg).—Mind, September (Williams and Norgate).—Bulletin of the United States National Museum, No. 35: H. Edwards (Washington).

CONTENTS.

THURSDAY, OCTOBER 17, 1889.

THE ELEMENTARY TEACHING OF SCIENCE.

PERHAPS the most important event in the Chemical Section at Newcastle was the presentation of a second Report (the first part of which we print elsewhere) by the Committee[1] appointed "to inquire into and report upon the present methods of teaching chemistry." It is a remarkable fact that the daily Press in general has made only the barest possible reference to the Report or to the animated discussion which followed its reading; although, as the *Times* points out, "there is a Committee attached to Section B, the professed purpose of which is to inquire into and report upon the teaching of chemistry; the truth is, however, that it involves the wide question of science teaching in general. The national importance of such an inquiry is evident, and it behoves all the Sections to take an interest in it."

At the Bath meeting the Committee reported on the condition of chemical teaching in the principal public schools of Great Britain and Ireland, their Report being founded upon information obtained from the principals, head masters, and science masters of these schools. This Report demonstrated the existence of a most unsatisfactory state of things. It proved unquestionably that physical science still occupies a very subordinate position in most of our public schools, and it appears that this is the result, in no small measure, of the manner in which it is taught. The attempt to cram the minds of boys with a conglomeration of chemical facts under the name of "science" has reached a crisis; and head masters, and even some parents, are beginning to feel, and to say in so many words, that science teaching, which has been on its trial for so many years, has failed to produce the educational effect which was expected from it. The teachers, while complaining of the various difficulties which surround their attempts to teach chemistry, *e.g.* insufficient time and laboratory accommodation, frankly admit that the methods at present employed in teaching the science are for the most part ineffective, and that to this circumstance may be attributed, in the majority of instances, the inferior position which is assigned to the subject in the school curriculum. Partly in self-justification, and partly as an explanation of the continued existence of these abortive methods, teachers have drawn attention to the requirements of the various examining bodies by which their hands are tied. It is rare to find the science master who is free to break away from conventional lines, and to use chemistry in illustration of the scientific method of questioning Nature, instead of relating to his boys the properties of all the elements from hydrogen to uranium, and by a system of laboratory drill instructing them how to "test" rare compounds or absurdly complex mixtures. Of the few examinational schedules which are likely to assist the teacher in making his elementary instruction in science most useful as an educational instrument, special mention may here be made of the syllabus of physiography issued by the Science and Art Department, having been drawn up by Mr. Norman Lockyer, and of the syllabus issued by the same Department for the "Alternative First Stage in Chemistry" (why should not this be made *the* "First Stage in Chemistry"?), which was compiled by two members of the present Committee, Sir Henry Roscoe and Dr. Russell.

The Committee thought that they might be able to do something towards a reorganization of elementary instruction in science; in fact several teachers had pointed out that the Committee were most favourably constituted for taking such action, and that they would doubtless be able to induce examining Boards to reconsider their present regulations.

About the middle of the present century two schools of educational authorities were actively engaged in propagating their views. The one school contended that the object of primary education should be to teach those subjects which can be practically applied in after life, while the other asserted that its main object should be to develop the faculties and not merely to store the mind with knowledge. Chemistry, no doubt, was introduced into the school curriculum chiefly to satisfy the demands of the first theory, but nevertheless it may equally well serve the purposes of the second. The mental discipline afforded by chemical investigation in developing the powers of observation and inference, and in teaching the correct use of hypothesis, is not less conspicuous than the many applications of which the science is susceptible both in industrial and "common" life. Happily, of late years, a fusion of these two theories has taken place, and agreement has very generally been reached on two important points. First, that the main purpose of elementary education should be to train the intelligence. In this sense "education is a high word—it is nothing less than the formation of mind." Secondly, it is admitted that before a man can apply science to practice he must be familiar with its methods, his mind must be able habitually to perform those logical processes which accurate thought demands. We are now fairly unanimous in the opinion that it should be the endeavour of elementary education to develop habits of correct observation and reasoning, so that in later life the more advanced knowledge of science, which will subsequently have been acquired, may be intelligently applied to the solution of social and industrial problems.

In the opinion of the Committee, this training of the intelligence can be readily effected by a properly arranged course of elementary instruction in physical science. This fact is, however, not recognized by the majority of educational authorities, since chemical teaching, which represents physical science in most schools, has hitherto been chiefly directed to the acquisition of a vast number of chemical facts. But the "learning of true propositions, dogmatically delivered, is not science," and does not produce any mental effect that cannot as well be reached by many other paths, *e.g.* the multiplication table and the facts of English history. So far, the public in this country have had very few opportunities of judging of the educational value of physical science, and it is to be feared that they have not yet sufficiently recognized the truth and significance of Herbert Spencer's definition of

[1] Consisting of Prof. H. E. Armstrong, F.R.S., Prof. W. R. Dunstan (Secretary), Dr. J. H. Gladstone, F.R.S., Mr. A. G. Vernon Harcourt, F.R.S., Prof. McLeod, F.R.S., Prof. Meldola, F.R.S., Mr. M. M. Pattison Muir, Sir Henry E. Roscoe, F.R.S., Dr. W. J. Russell, F.R.S. (Chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. G. Stallard.

science as "trained and organized common-sense," which implies that those same mental processes whose use has led to great scientific discoveries are also applicable to even the commonest affairs of life with equally successful results. In order to make chemistry subservient to the needs of mental education, it is necessary to depart almost entirely from the usual method of teaching it, which is better adapted for the subsequent training of those comparatively few students who intend to follow chemistry as a profession. Instead of attempting to traverse the greater part of the science, the teaching must be restricted to those portions of it which best exemplify the scientific method of investigation; and it should, as far as possible, have reference to objects which are more or less familiar to the pupils, or which can be readily understood by them.

The Committee having agreed as to the principles on which a scheme of elementary instruction should depend, Prof. Armstrong undertook to prepare a series of suggestions for an actual course of instruction in sufficient detail to serve as a general guide to teachers. These suggestions form a part of the Committee's Report, and are of very considerable importance. The course is divided into six "stages." Stage I. deals with lessons on common and familiar objects; the classification of these according to their uses and origin; elementary physiography and *Naturkunde*. Stage II., with lessons in measurement. Stage III., with studies of heat on things in general; of their behaviour when burnt. Stage IV., the problem stage—to determine what happens when iron rusts; to determine the nature of the changes which take place when substances are burnt in air; to separate the active from the inactive constituent of air; to determine the composition of chalk; to determine what happens when organic substances are burnt; to determine what happens when sulphur is burnt; to determine what happens when metals are heated with acids; to determine what happens when oxides are treated with acids; to determine what happens when the gas obtained by dissolving iron and zinc in sulphuric acid or muriatic acid is burnt; to determine what happens when hydrogen and other combustible substances are heated with oxides; to determine whether oxides, such as water and chalk gas, may be deprived of oxygen by means of metals; to determine the composition of salt-gas and the manner in which it acts on metals and oxides; to determine the composition of washing-soda. Stage V., the quantitative stage: study of the quantitative composition of some of the substances which have already been qualitatively examined. Stage VI., studies of the physical properties of gases in comparison with those of liquids and solids; the molecular and atomic theories, and their application.

Without pledging themselves to accept every detail, many of which would naturally be modified by teachers to suit their own special cirumstances, the Committee state that Prof. Armstrong's suggestions are typical of the kind of instruction which they wish to see generally introduced into schools. They prefer to speak of it as a course of elementary instruction in "physical science," since, although it is mainly chemical, physical problems are largely introduced, and the course, as a whole, may be looked upon as a suitable introduction to the study of any of the physical sciences.

In bringing this scheme under the notice of teachers, the Committee make several recommendations as to the manner in which it should be carried out, but these can only be briefly alluded to here. They insist that the instruction should be commenced with young children, and that every pupil in the school should receive it. In order that it may be successful, a fair share of the school time must be devoted to the subject, and a larger number of teachers must be employed than is now usually the case. While this may lead to some extra expense, on the other hand it is pointed out that the simplest laboratory fittings and apparatus are all that will actually be needed. Thus the expenditure attending the adoption of the new course need not be greater than it is now in those schools where science teaching occupies a prominent place among the subjects of study.

Space does not allow of more than a passing mention of the series of statistics in reference to the teaching of chemistry in public elementary schools which have been admirably collected and commented upon by Prof. Smithells, and which form the second part of the Report. As in the higher public schools, the teaching of elementary science in these institutions is shown to be far from satisfactory, and here also a scheme of the kind suggested by the Committee might be introduced with very great advantage.

In the discussion which followed the reading of the Report the Committee had the satisfaction of learning that their recommendations receive the approval of several teachers of experience. A representative of Section E stated that those interested in the efficient teaching of geography felt strongly that the course of work advocated by the Committee was on the proper lines. The head master of a large elementary school complained of the present methods of teaching chemistry, and stated that they tended so strongly towards making those who followed them into professional and technical chemists, that he had been obliged to substitute for chemistry instruction in some other branch of science. A useful contribution to the discussion was made by a former assistant science master in one of the largest public schools in London, who gave a graphic account of the hardships which were suffered by the solitary science master and his assistant in their efforts to teach "practical chemistry" to large classes of boys. If the comparison he instituted between the methods respectively adopted in this school in teaching classics and science be true, and if his statistics are correct as to the number of boys who are "taught" science, and the number of masters employed to teach them, they reveal a scandalous state of affairs, which no City Company ought to tolerate in a school which it endows. Finally, Prof. Armstrong read letters which he had received from Prof. Huxley, the head master of Rugby, Sir Philip Magnus, and other authorities, in which they spoke with approval of the scheme for science teaching which the Committee advocate in their Report.

It seems likely, then, that through the action of this Committee a considerable impetus in a new direction will be given to the elementary teaching of science in this country. The words which Mark Pattison wrote more than twenty years ago are as true now as they were then, and may appropriately bring these remarks to a conclusion. "The dispute between science *versus* classics in education will not be settled on paper or by discussion. It will be settled, in fact, by the establishment somewhere or other, and in some form or other, of a system of scientific education, the results of which will vindicate themselves. We may argue, and vested interests may resist, but the tendency of things is unmistakable—the sciences will end by conquering their place."

W. R. D.

CORRESPONDENCE OF CHRISTIAN HUYGENS.

Œuvres Complètes de Christiaan Huygens. Publiées par la Société Hollandaise des Sciences. Tome Deuxième: Correspondance, 1657–59. (La Haye: Martinus Nijhoff, 1889.)

THE second volume of the great edition of Huygens's works, the first volume of which was noticed last year in these pages (NATURE, vol. xxxviii. p. 193), has made its appearance with creditable promptitude. The letters included in it range from 1657 to 1659. That they are numerous and elaborate is sufficiently shown by the bulk of their receptacle; their value might be taken on trust from the names of the writers, and can be ascertained by the somewhat laborious process of perusal. This, however, may be curtailed at pleasure by having recourse to a series of admirably-constructed indexes, aided by which, readers, exempted from the ignominious necessity for "skipping," are enabled to find what they want, and neglect what less immediately concerns them.

Scientific correspondence was in those days of far greater importance than it is now. It, in fact, to a great extent, took the place of scientific journalism. There was then no recognized channel of public criticism. The first numbers of the *Philosophical Transactions* and the *Journal des Savans* appeared within a few months of each other in 1665; the *Acta Eruditorum* began to be published at Leipzig only in 1682. The learned formed a cosmopolitan caste, using a cosmopolitan language. They made an audience "fit and few" for each other's communications, and cared little, in general, to address a wider public. Epistolary intercourse assumed, accordingly, proportions and a significance which we find it difficult to realize. From one end of the Continent to the other, workers were, by means of letters nominally private, kept *au courant* of the progress of invention, readers of the course of publication; ideas and criticisms were interchanged; authors were informed of the impression produced by their works; controversies were conducted or commented upon.

In the correspondence now before us, indeed, there is small trace of the *odium scientificum.* Although often obliged to stand on the defensive against unjust attacks upon his originality, Huygens never lost self-control. The *scelerata insania belli* had no place in his calm and reasonable mind. His reticence is strikingly illustrated by the incident of the feigned anagram, left unfinished and mysterious by the earlier letters, but brought to a satisfactory conclusion in the present collection. The bogus claim put forward by Dr. Wallis to the detection of Saturn's first-known satellite, proves, in accordance with the conjecture emitted by Mr. Maunder in the *Observatory* for last March, to have been an infelicitous practical joke. It enforced, however, a designed moral by rendering palpable the protective inefficacy of crytographical announcements; and no more was heard (that we are aware) of the entrenchment of discoveries or inventions behind logogryphs. Huygens continued in a state of mystification on the point for above three years, the Savilian Professor's first explanatory letter having miscarried; but he allowed his natural irritation only the vent of a few jottings of a strictly private character.

The publication of Huygens's "Systema Saturnium" was the leading event of the period now under consideration. The book was long and eagerly expected, and was received—so far as letters acknowledging the receipt of "complimentary copies" enable us to judge—with a chorus of approbation. Its author, at the age of thirty—Galileo being already dead, and Newton as yet unknown—found himself pre-eminent among the astronomers of Europe. "*Ora ha Giotto il grido.*" Yet the flattering assurances with which he was overwhelmed did not wholly exclude some expressions of misgiving. The physical and mechanical difficulties attending the existence of such a Saturnian system as he described were very great. The hypothesis of a ring was no doubt beautifully ingenious, and accounted for observed phenomena with the utmost neatness and sufficiency; but was it true? Was such an incredible structure, in point of actual and undeniable fact, to be found in the heavens? Such questionings could not but arise, and were only finally set at rest by the predicted complete disappearance of the anomalous appendages as the earth got to the unilluminated side of them towards the end of 1671.

Saturn's ring-system has now so long held a place in astronomical consciousness that it costs an effort of the imagination to conceive the audacity of the first attempt to establish it there. Its author himself did not look for immediate and unqualified assent. All he hoped for was that his mode of accounting for the "bizarre appearances" of the "triple planet" should get an unprejudiced trial. Writing to Slusius in September 1659, he congratulated himself that his hypothesis had not struck him as absurd; and he met the scruples of objectors with a quiet appeal to time. It has not failed to justify his confidence.

An incidental paragraph in the "Systema Saturnium" (p. 9), announcing the virtual discovery of the great Orion nebula, appears to have excited little attention. Huygens's correspondents passed it over in silence; he took no trouble to invite their opinions on the subject; nor is there evidence that any of his subsequent observations were directed towards that "gap" (as it were) in the crystalline vault through which the glimmering of empyreal fire was discernible. Still more singularly, Hevelius, although he catalogued the stars, and enumerated fourteen nebulæ, did not include among them the Orion "portent," upon which, indeed, he seems never to have had the curiosity to direct his telescope (H. Schultz, *Astr. Nach.*, No. 1585). The first intelligent observer of nebulæ was Halley.

A sidereal phenomenon of another sort, however, attracted considerable attention in the learned *côteries* of Paris and the Hague. Janson's "new star," *in collo Cygni*, was again visible in 1658–59. First seen in 1600 as of the third magnitude, it disappeared from view in 1621, but was re-detected, in its pristine brightness, by Domenico Cassini at Bologna in 1655. The news seems to have taken no less than three years to filter to the Low Countries. Golius, of Leyden, was one of the first to get hold of it, and he transmitted it to Boulliau, of Paris, who thereupon perceived, plainly enough, a brilliant star shining in the place of a usually telescopic one. As an example of mental inertia comparable to that afforded by Hevelius with regard to the Orion nebula, it is worth noting that the object had caught his eye twelve days previously, but without rousing his attention. He imparted to Huygens his conviction that the Milky Way "provided the material for such generations," among which he included comets; and judiciously wound up his speculations by urging the necessity for continued observation.

His correspondent had anticipated the recommendation. His interest in the "renaissante of the Swan" (as he termed it) is shown by various remarks; but a more formal essay on the subject, alluded to in a letter to the Sicilian astronomer Hodierna, has not been preserved. Huygens considered the star, on November 20, 1659, to have lost none of its lately-acquired brilliancy. Boulliau, however, had already noticed a diminution in *size*, though not in *lustre* (a distinction to which he evidently attached some importance), and on December 12 saw further symptoms of fading in its pale and languid aspect. From the decline which then set in, it has never completely recovered, but has remained, since the abortive maximum of 1665, undistinguished by conspicuous vicissitudes. "P Cygni," as Janson's star is called in modern nomenclature, now betrays peculiarity of constitution only by the bright hydrogen lines photographically discovered by Prof. Pickering in its spectrum.

Huygens's invention of the pendulum clock is a prominent topic in the correspondence before us. He was not without hope of solving, by its means, the ever-recurring problem of longitudes, "if only it would bear transport by sea"—a prudent qualification. Of curves and quadratures, telescopes and lenses, chronometry, meteorology, mechanics, the theory of numbers, much is said, showing the working of thought along these various lines of research. There is scarcely, in fact, a branch of scientific history which is not usefully illustrated by these valuable letters.

A. M. CLERKE.

THE ANATOMY OF THE HUMPBACK WHALE.

The Anatomy of the Humpback Whale (*Megaptera longimana*). By John Struthers, M.D. (Edinburgh: 1889.)

THERE is probably no order of Mammals which during the last twenty-five years has been more worked at than the Cetacea. The result has been that we now possess a valuable body of information on both the classification and anatomy of this most interesting group of animals. On the continent of Europe, the names of Eschricht, Reinhardt, Lilljeborg, Van Beneden, and Gervais stand out most prominently as authorities; whilst in this country Sir Richard Owen, Profs. Flower, Struthers, and Turner, Dr. Murie, and Prof. Macalister, have all written valuable memoirs which have added largely to our knowledge of the whales. Through the combined labours of these anatomists the order has been rescued from the state of confusion into which it had been thrown by some systematic writers, who, by regarding almost every specimen stranded on our coasts as a new species, had introduced a complexity of nomenclature which was most puzzling.

The humpbacked whale, the anatomy of which forms the subject of Prof. Struthers's memoir, is, from its form and structure, one of the most interesting of the occasional visitors to our coasts. The number of specimens the capture of which has been recorded in British waters, prior to that of the specimen dissected by Dr. Struthers, was only three: viz. a female cast ashore near Newcastle in September 1829, and described by the late Dr. George Johnston; another female taken in 1863 in the estuary of the Dee, the skeleton of which is in the Derby Museum, Liverpool; and an adult towed into Wick Bay in March 1871, the skeleton of which was not preserved. This whale is, however, not uncommon in the North Atlantic, more especially off the coasts of Norway and Finmark, and in the seas of Iceland and Spitzbergen.

The specimen described in Prof. Struthers's memoir was seen in the Firth of Tay, in the month of December 1883. It was harpooned, but broke away from its captors, was ultimately found floating dead off Bervie, and was towed into Stonehaven Harbour on January 8, 1884. It is fortunate that it fell into the hands of so competent an anatomist and so enthusiastic a cetologist as the Aberdeen Professor. Thanks to his untiring energy and industry, he has furnished us with a monograph on the external characters, the skeletal anatomy, the muscular anatomy of the pectoral limbs, and the connections of the pelvic bones and rudimentary hind limbs of this animal, far more precise and detailed than had been given by any previous anatomist. He has added also greatly to the value of his description by instituting a comparison between the skeleton of Megaptera and that of *Balænoptera musculus*. The memoir will have to be studied by all cetologists who wish to have an exact knowledge of the anatomy of this great baleen whale.

OUR BOOK SHELF.

First Mathematical Course. Blackie's "Science Text-Books." (London: Blackie and Son, 1889.)

THIS little work, comprising arithmetic, algebra (as far as simple equations), and the first book of Euclid, is adapted to the requirements of the examinations of the Science and Art Department in mathematics (Subject V.), first stage. The more elementary parts of arithmetic have been briefly treated, as the pupil will have most probably reached fractions, but great attention has been paid to the examples, which are both numerous and judiciously chosen. The algebraical part is completed up to and includes simultaneous equations, and here, as in the arithmetical part, we have a great number of well-arranged examples, including those set for this stage in previous examinations. Part III. consists of the first book of Euclid with exercises on the various propositions. Preceding the answers to the examples is an appendix containing specimen examination papers set by the above-named Department. Teachers, who require a great number of easy examples on these three branches of mathematics, will find this book very useful.

Key to Todhunter's Integral Calculus. By H. St. J. Hunter, M.A. (London: Macmillan and Co., 1889.)

ALL the examples in Todhunter's "Integral Calculus" are fully worked out in this volume. In the earlier chapters, the solutions are exhibited with considerable detail, so that the "Key" will be a valuable aid to those who are beginning the subject without the help of a teacher. Throughout the work many references are made to the text, the edition referred to being that of 1886.

The Hand-book of Jamaica for 1889-90. By A. C. Sinclair. (London: Edward Stanford. Jamaica: Government Printing Establishment.)

THIS is the ninth annual issue of Mr. Sinclair's "Handbook," and to those who have already had occasion to consult the work we need hardly say that it contains all the information, clearly and compactly presented, that is likely to be wanted by its readers. The writer provides a good description and historical sketch of Jamaica, and full details are given with regard to all the leading institutions of the island. The volume is published by authority, and has been compiled from official and other trustworthy records.

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 Method of Quarter-Squares.

MAY I point out, by way of note to Mr. Glaisher's article (October 10, p. 573) on the method of quarter-squares, that the method is indicated in the second edition of Sir John Leslie's "Philosophy of Arithmetic" (Edinburgh, 1820; see pp. 246–57). Leslie gives what he calls a "specimen" table, extending as far as 2000, whereby any two numbers containing not more than three digits each can be multiplied; and he also points out the application of the table for any two numbers less than 2000 by using the formula—

$$ab = 2\left\{\frac{a^2}{4} + \frac{b^2}{4} - \frac{(a-b)^2}{4}\right\}.$$

Apparently, Leslie was an independent discoverer of the method; at least this seems to be implied in the remarks which follow his table in the work cited above:—"This application of a table of quarter-squares, as it is derived from the simplest principles, might have readily occurred to a mathematician; yet I have nowhere seen it brought into practical use till, last summer, I met with, at Paris, a small book by Antoine Voisin, printed in 1817. It contains a table of quarter squares for the multiplication of whole numbers from 1 to 20,000, with an explanation of the mode of employing them." G. CAREY FOSTER.

University College, London, October 13.

Marine Biological Association.

THE British Association, at the recent meeting at Newcastle placed a grant of money in the hands of a Committee, consisting of Prof. W. H. Flower, Prof. M. Foster, Prof. E. Ray Lankester, Prof. S. H. Vines, and myself (Secretary), "for the purpose of nominating students to work at the Laboratory of the Marine Biological Association at Plymouth." Arrangements are being made with the Council of the Marine Biological Association, by which the Committee hope to obtain the use of a table at the Laboratory at Plymouth for twelve months.

May I ask you to assist, through the medium of NATURE, in making this information public? Persons who wish to take advantage of the opportunity, afforded by the British Association, of working at the Plymouth Laboratory should address their applications to me at the earliest possible date. The application should contain full particulars as to the nature of the investigation which it is proposed to carry on, together with a statement of the period of time during which the applicant would be able to work at Plymouth. S. F. HARMER.

King's College, Cambridge, October 15.

Section Work at the British Association.

THE recent meeting at Newcastle has emphasized what has been frequently noticed before, that the British Association week undoes the benefit of previous holiday, and that the conditions under which the work of the Sections is carried on are prejudicial to health, and have this time resulted in a considerable list of sick and wounded. I speak especially of Section A, but have no reason to suppose it different from others.

The principal difficulty is the elementary one of food. A satisfactory midday meal is at present practically unattainable, unless one is willing to sacrifice everything else to it. The time of meeting (from 11 to 3, or, for those more intimately connected with the business of the Sections, from 10 to 5) and the practice of non-adjournment for lunch are to blame for this; and I write to raise the question, whether it may not be wise to reconsider the time-honoured meeting-hours both of Sections and of Committees. Several proposals can be made, but the one I wish to bring forward is, to postpone the Sectional Committee meetings till after the Section has sat, and to begin the Section work at 10 a.m. The work should begin then more freshly than it does now after an occasionally tedious, though occasionally interesting, Committee meeting; and it may go on steadily till 1.30, when it will usually stop for the day. At 2.30, or possibly, but less advantageously, at 2, the Sectional Committees can meet and transact their business comfortably. It will be easier to arrange the papers for next day when it is known how many stand over from the recent meeting; and as the Secretaries usually have things pretty well arranged beforehand, there need be no difficulty or delay in getting the list to the printer in good time. The important business of appointing Committees and such-like can be discussed very rationally after the Committee or individual has just reported to the Section, instead of, as at present, before such report. At 3.30 the General Committee and the Committee of Recommendations can meet, instead of at 3. This apparent lengthening of the day's work by half an hour will be more than compensated by a comfortable sit-down lunch, and one useful function of the Association, viz. the interchange of ideas in conversation, will be much assisted. It may be objected that, if all the Sections rise at 1.30, the luncheon-room will be inconveniently crowded, but there are usually many clubs and private houses available; and if a midday meal became a feature, there is no lack of hospitality. The usual difficulty is how to fit anything social into the crowd of engagements and evening lectures.

My proposal curtails the Section time by half an hour. Whether this is regrettable or not, I am not sure: there are ways of avoiding it if it is. If any hard-pressed Section chooses, it might meet again at 3.30 on every day but Monday, and sit, concurrently with the Committee of Recommendations, for an hour or two without essential hardship. What I feel sure ought to be reconsidered, is the present health-destroying practice of continuous session. OLIVER J. LODGE.

Anthropometric Measurements at Cambridge.

I QUITE agree with your correspondent "F. M. T." that the head measurements are not sufficiently accurate to warrant their use as data for coming to any conclusion as to increased cranial capacity, much less as the foundation for the theories of Mr. Francis Galton. On a comparison of the head measurements of any one individual, they are found to be so variant that one is forced to conclude that the errors of observation are far greater than the maximum error which could exist without completely vitiating the trustworthiness of the data. The following measurements of my head during the last two years are sufficient to render this obvious—

	Breadth.	Length.	Above line from brow to ear-lobe.	Total.
May 28, 1887	5·7	7·4	5·3	223·55
November 19, 1887	5·6	7·3	5·5	224·84
June 14, 1888	5·8	7·4	5·5	236·06
February 4, 1889	5·7	7·3	5·2	216·37
August 23, 1889	5·8	7·5	5·4	234·90
August 30, 1889	5·8	7·4	5·6	240·35

I would particularly call attention to the third and fourth measurements, as also to the last two, and venture to think that no one could entertain the trustworthiness of data that involve such great changes in cranial capacity in such short spaces of time. To what, then, are these differences due? Partly, of course, to unavoidable errors of observation. This, however, I think is only a small portion of the differences. The main difference is, I believe, due to other causes. Anyone who has seen the instruments will recognize that they are far too rough and imperfect to measure small differences with any degree of accuracy, and yet it is on differences as small as one-tenth of an inch that Mr. Galton's calculations are based.

I admit it is quite possible that, even after elimination of the errors due to experimental causes and to the imperfection of the instrument, the figures would still be somewhat variable. These variations may, however, be readily explained, without the assumption of any improbable head-growth. The amount of hair on the head must considerably influence the measurements, and, according as it is long or short at the time of measurement, so will the figures show an increase or a decrease. I have tested this, and proved it to be the case. On August 30 (my hair not being very long, having been cut two and a half weeks previously) my head was measured, the figures being as follows:—

$$5\cdot8,\ 7\cdot4,\ 5\cdot6 = 240\cdot35.$$

I then had my hair cut fairly short, and was measured again; the figures then read—

$$5\cdot7,\ 7\cdot4,\ 5\cdot5 = 231\cdot99.$$

Again, the scalp being, as is well known, very vascular, any change in the fulness of its vessels must materially affect the thickness of the scalp, and so influence the measurements, and so any cause producing either increased blood-flow or hindering the return of blood from the scalp, will have some effect on the measurements.

Several other similar explanations of supposed head-growth might be given, but I think the measurements I have given will suffice to show the uselessness of the measurements for calculating head-growth, and, further, that such differences as actually do exist can be readily explained without having recourse to any such improbable assumption as the further growth of the head after nineteen years of age, and without involving the unintelligible statement that the head of a "poll" man grows more than the head of an honour man. This would necessitate the supposition that a "poll" man, by his three years' study (?) at Cambridge, profits more than an honour man! Such an hypothesis would need more scientific proof than has been given.

Trinity College, Cambridge, September 3. H. J. P.

Glories.

COLOURED rings are often seen surrounding the shadow of the spectator's head when the sun is shining on a fog of water particles. They are known by various names, such as glories, anthelia, Ulloa's rings, &c. Can any of your readers inform me if they can also be seen when the fog is frozen? I should also be glad of accurate accounts of their colour and angular dimensions. I have read those given by Scoresby (Kaemtz, "Meteorology," translated by Walker); Flammarion (Glaisher's "Travels in the Air"); Abercromby (*Phil. Mag.*, January 1887); and Mohn (NATURE, February 1888).

JAMES C. MCCONNEL.

Hotel Buol, Davos, Switzerland.

Fine Slow-moving Meteor.

ON September 25, at 8h. 5m., I saw a bright first-magnitude meteor amongst the stars of Aquarius. It moved very slowly to the east, and, after a duration of about 13 seconds, disappeared at the point R.A. 11°, Decl. + 8°. Its place of first appearance was near R.A. 332°, Decl. $-7\frac{1}{2}°$, so that the length of its observed path was about 42°. The nucleus was followed by a thick train of sparks, and at the end it divided into two parts. This meteor was observed at Oxford by Mr. W. H. Robinson, of the Radcliffe Observatory. He writes:—"This evening a fine meteor was seen slowly moving between the constellations Aquarius and Pegasus, at 8h. $5\frac{1}{2}$m. G.M.T. It was first seen at R.A. 330°, N.P.D. 88°, disappearing near R.A. 352°, N.P.D. 82°; duration, 3 or 4 seconds." A comparison of these observations shows that the radiant point was probably in R.A. 244°, Decl. − 22°, and that the meteor, when first seen, was at a height of 46 miles over a point in the English Channel 20 miles south of the Isle of Wight. It disappeared near Staplehurst, in Kent, at the same height. Length of path, 100 miles. At Oxford, the early part of the meteor's flight was not seen. The Bristol observer watched the meteor through 91 miles of its course, and the duration of 13 seconds would give a velocity of 7 miles per second. At Oxford, 35 miles of the terminal section of the flight was seen in 3 or 4 seconds, which gives a velocity of 10 miles per second.

Further observations of this body would be valuable to corroborate these results. The meteor was an exceptional one, both as regards its slow speed and the position of its radiant point. No meteor-shower has hitherto been recognized at this epoch in the region of Scorpio. Isolated slow-moving meteors of this description are of great value as giving us indications of feeble systems not otherwise discoverable, and as allowing good determinations to be made of their heights and velocities.

Bristol, October 4. W. F. DENNING.

A Brilliant Meteor.

AT 7h. 6m. ± p.m. G.M.T., on October 10, a brilliant meteor was observed here, about 10° south-west of α Pegasi, and travelling from thence to near Jupiter, being apparently three times the size and brilliancy of that planet. Its colour was of a bluish-white, and it possessed a fine train, disappearing after six seconds, having burst into a number of pieces. W. HUGO.

Kew Observatory, Richmond.

The Shining Night-Clouds—An Appeal for Observations.

THE following is the substance of an appeal for observations made by Herr O. Jesse in the spring. The time of year in which the clouds appear in these latitudes has now elapsed; I have seen no sign of them this summer, either in this country or while travelling in the Alps. But as Mr. D. J. Rowan saw them (see NATURE, June 13, p. 151) it is very desirable that they should be looked for in all parts of the world. I see Mr. Le Conte assumes (October 3, p. 544) that Mr. Rowan is correct in calling these clouds self-luminous—which conclusion I agree with Herr Jesse in considering highly improbable.

Sunderland, October 12. T. W. BACKHOUSE.

The time of year has again arrived when the lustrous silvery clouds, which have appeared annually in June and July from 1885 to 1888, may be expected to again become visible to observers throughout Europe.

These clouds are not only of high meteorological interest, but may be of an almost greater astronomical one, for, from their so decidedly pronounced periodicity, joined to their extraordinary height, it may perhaps be inferred that they are of extra-terrestrial origin.

As there is entire lack of previous record of these clouds, and they may disappear soon for an indefinite period, I would earnestly ask for such early observations as may be likely to determine their origin, nature, and periodic motion. Spectroscopic examination of their light would be valuable. Prof. Galle and others have considered that the clouds in question are phosphorescent, but this is very improbable, and I hold they are scarcely, if at all, visible unless the sun shines directly upon their substance. On this assumption, their height in 1885 was found to be from 49 to 54 kilometres; but, by photographic observations in 1888, it came out as great as 75 kilometres.

Prof. Kohlrausch advances the opinion that these clouds have in some way been formed by the eruption of Krakatão, although they were not generally seen until nearly two years after that event. From this hypothesis I suggest that they may be caused by the condensation of gases from that volcano, and that the process of condensation occupied the intervening time. One observer, however, states that he saw them in 1884.

NOTES.

WE deeply regret to have to record the death of James Prescott Joule, one of the greatest men of the age. He died on Friday last at his residence at Sale, near Manchester.

PROF. H. G. SEELEY, who has recently returned from an expedition to South Africa, has obtained from the Karroo, among a large number of other treasures, a complete specimen of the much-discussed *Parieasaurus*.

THE ordinary general meeting of the Institution of Mechanical Engineers will be held on Wednesday, October 30, and Thursday, October 31, at 25 Great George Street, Wesminster. The chair will be taken at half-past seven p.m., on each evening, by the President, Mr. Charles Cochrane. The following papers will be read and discussed, as far as time permits:—On the results of blast-furnace practice with lime instead of limestone as flux, by the President; description of a rotary machine for making block-bottomed paper bags, by Mr. Job Duerden, of Burnley, communicated through Mr. Henry Chapman; further experiments on condensation and re-evaporation of steam in a jacketed cylinder, by Major Thomas English, R.E., Superintendent, Royal Carriage Department, Woolwich.

THE Government of Victoria has definitely deputed Mr. James Stirling, Assistant Geological Surveyor in the service of the Government, to make a thorough and systematic survey and mapping of the coal districts in the colony. This step has been taken in consequence of the suggestions of Sir James Hector, the Director of the Geological Survey of New Zealand, who, during a recent visit to Victoria, examined the supposed coal-bearing seams, and reported favourably on them. The great drawback to Victorian prosperity so far has been the absence of coal deposits.

THE *Civil and Military Gazette* of Lahore says that Mr. Dauvergne has succeeded in erecting a monument to the memory of Mr. Dalgleish, where the latter was murdered at the foot of the Karakoram Pass two years ago.

DR. A. ALCOCK, of the Indian Marine, has been deputed to examine and classify the collections which the Indian Marine Survey has made over to the Imperial Museum, Calcutta, during the past few years.

THE cultivation of the Egyptian date-palm in India is to be tried on a large scale, and an order for over 700 off-sets and three maunds of seed has been sent to Egypt. It is intended that the consignment shall be distributed in the Punjab, Bombay, Madras, Rajputana, and Coorg, for experiment.

THE *Kew Bulletin* for October opens with a paper on a valuable fibre, largely used in this country under the name of Bahia piassava. This fibre is obtained from the leaf-stalks of a Brazilian palm known as *Attalea funifera*, Mart., and is used in the making of brushes and brooms. Some interesting remarks on the condition of the industry in Brazil, by Mr. W. S. Booth, are presented in the paper. In another paper there is a letter, addressed by Mr. D. Morris to the Colonial Office, on the treatment of seedling sugar-canes at Barbados, and of any that may be found in other sugar-producing colonies in the West Indies. The remaining subjects dealt with are cinchona in Jamaica; the commercial product called gambier, used by tanners; and the fibre industry at the Bahamas.

THE *Photographic Quarterly*, if we may judge from the first number, is likely to be of great service to all who interest themselves in the study of photographic methods. It opens with a series of hints, by the Rev. T. Perkins, on the production of pictures by photography. Among the other articles are "Chemistry and Photography," by C. H. Bothamley; "The Influence of Photography on Art, and its Consequences," by A. M. Rossi; "A Plea for Photogravure," by Major J. F. Nott; "Photo-micrography," by J. Hall-Edwards; and "New Method of Printing in Clouds in Lantern Slides," by Lionel Clark. A portrait of Mr. James Glaisher, F.R.S., President of the Photographic Society of Great Britain, accompanies the first number. There is also a view of Salisbury Cathedral from the Bishop's garden.

THE Pilot Chart of the North Atlantic Ocean for the month of October shows that September was very stormy, especially off the American coast and in the West Indies. Low barometer, accompanied by gales, prevailed along the transatlantic routes from the 4th to the 15th inclusive. The most notable disturbance was the West India hurricane, which seems to have originated east of the Windward Islands at the end of August, reaching Antigua and Martinique on September 2, and continuing with unabated force in a west-north-west direction until the 12th. The large area and the severity of this hurricane make it one of the most notable on record, and it is the subject of a special appendix, with charts, showing its behaviour over the ocean during each of ten days. The rapidity with which these charts have been published is, we believe, unequalled in maritime meteorology, and indicates, as stated in the remarks, the cordial support that the Washington Office receives from masters of vessels in its efforts to collect and utilize maritime data. There was a marked diminution of fog during the month, and an unusually large amount of ice as far as the 49th meridian, and even south of the 50th parallel.

THE appendix to the Bulletin of the New England Meteorological Society for the year 1888, shows that the number of stations constituting that weather service amounts to 172. The year was, on the whole, cool and wet, and some of the cyclones, of which 88 are classified according to the direction of their paths, were of great violence. Thunderstorms were very numerous, and in some cases destructive. A marked peculiarity of the year was the heavy rainfalls which occurred in the last six months. In the five months August to December the excess was nearly 11 inches. The greatest and least movements of the wind, as shown by anemometrical records, were in March and June respectively; the largest totals for the year were at Blue Hill Observatory.

AT the meeting of the Linnean Society of New South Wales on August 20, Mr. J. H. Maiden read an interesting paper on spinifex resin. The resin examined was a sample obtained by Mr. W. Froggatt near Derby, North-West Australia, last year, and presented by Sir William Macleay to Mr. Maiden. It is in flat cakes, about 3 inches in diameter, has a dirty bronze-green appearance, and a persistent disagreeable odour not easily described. It consists of vegetable *débris* (which may prove to belong to a grass) cemented with a yellowish-brown resin, and containing about 3 per cent. of fat. Mr. Froggatt states that it is employed by the natives as a cement for spear-heads, &c.; and the consistent testimony of the natives, as well as of the Europeans, is that it is obtained from the roots of spinifex grass (*Triodia irritans*, R.Br.). As far as the author knows, the extraction of resin from a grass has never previously been recorded. The resin isolated bears no resemblance to any other Australian resin known to the author.

A SCHEME is now being matured to establish regular training schools for surveyors in the Straits Settlements. The demand for surveyors is very great on the part both of the Government and of private individuals, and this demand is sure to increase with the rapid development of the Malay Peninsula.

TECHNICAL instruction is receiving a good deal of attention in the Central Provinces of India. Under the new scholarship rules, high school scholarships are tenable in the engineering and agricultural classes which were opened last year at Nagpore, and College scholarships have also been reserved for engineering students who desire to study in some Engineering College, or in any superior School of Forestry. At present, the classes at Nagpore are not well attended. In the engineering class, thirty students entered, but only eleven passed the first year's course. It is, however, expected that a large number will enter during the coming session. There was an average of twenty-five students in the agricultural class. In connection with the latter class, the students are compelled to work with their own hands at all the ordinary agricultural processes, and each receives a plot of land, which he is expected to till as directed. Besides practical agriculture, the students are taught mechanical and chemical analyses of soils and practical field-surveying. Gardening and carpentry are also taught. One of the greatest hindrances to the progress of this and similar institutions in India is the dislike of the Brahmins to any manual labour; but the authorities do not despair of overcoming this difficulty.

SOME Italian observers have been recently testing the senses of criminals; and they find these duller than in the average of people. Signor Ottolenghi, in Turin, found, last year, a less acute sense of smell in criminals; and he now affirms the same for taste, which he tested by applying bitter and sweet substances (strychnine and saccharine) in dilute solution to the tongue. He finds also the taste of the habitual criminal less acute than that of the casual offender, and a slightly more acute taste in male than in female criminals. Experiments with regard to hearing were made by Signor Gradenigo (also in Turin); and of 82 criminals he found 55 (or 67·3 per cent.) to have less than the normal acuteness, the greatest inferiority being in the oldest. In female criminals the relations were somewhat better: 15 out of 28 had hearing under the average. The limits of variations in acuteness also appeared to be much wider in criminals than in normal persons. Ear disease was common. Signor Gradenigo attributes these things to bad hygienic conditions of life, and vicious habits.

MESSRS. MACMILLAN AND CO. have issued Part 2, comprising Book II., of the fifth edition of Prof. M. Foster's "Text-book of Physiology." The work has been largely revised.

THE sixth edition of the well-known "Treatise on Dynamics of a Particle," by Prof. Tait and the late Mr. W. J. Steele (Macmillan), has been issued. The work was begun by Prof. Tait and Mr. Steele towards the end of 1852, and first appeared in 1856. "At Mr. Steele's early death," says Prof. Tait in the preface, "his allotted share of the work was uncompleted, and I had to undertake the final arrangement of the whole. In the subsequent editions it has derived much benefit from revision: first by Mr. Stirling of Trinity in 1865, then by Mr. W. D. Niven of Trinity in 1871, and by Prof. Greenhill of Emmanuel in 1878. It last appeared after a general revision by myself, with the assistance of Dr. C. G. Knott and of my colleague Prof. Chrystal. The present edition has been prepared by me, with the assistance of Dr. W. Peddie."

THE second volume of the "Geological Record" for 1880-84 (inclusive) has been issued. It is edited by Mr. W. Topley, F.R.S., and Mr. C. D. Sherborn. The subjects to which the lists of publications relate are physical and applied geology, petrology, meteorites, mineralogy, mineral waters, and palæontology. There is also a division entitled "General," and another deals with maps and sections. A carefully compiled index adds to the value of the work. Mr. Topley and Mr. Sherborn appeal to editors, publishers, and authors to aid them in future labours by forwarding copies of their publications, especially pamphlets separately published, and new series.

MESSRS. DULAU AND CO. will publish, in December, a "Catalogue of British Fossil Vertebrata," by Arthur Smith Woodward and Charles Davies Sherborn. The volume will consist of about 350 pages, and will tabulate the results of researches upon the British fossil Vertebrata since the time of Linnæus. The nature of the type specimen in each case is stated, and, whenever traceable, the museum or collection in which it is now preserved is mentioned. Special attention has been given to the distribution of the Pleistocene Mammalia.

WE have received from Napier, New Zealand, a copy of a pamphlet containing some papers on Maori folk-lore read before the Hawke's Bay Philosophical Institute by Mr. William Colenso. The first is entitled "Ancient Tide-lore and Tales of the Sea," and gives the Maori lore on the cause of the tides, on the sounding, or, as it is styled in Cornwall, the "calling," of the sea. These are followed by other Maori stories from the east coast of New Zealand, translated with explanatory notes. The whole forms one of the most charming contributions to folk-lore that have ever come under our notice.

IN his last Report to the Foreign Office on the agricultural condition of Colombia, the British Consul at Bogota says that the potato is the chief food of the people of the cold part of that country. Two principal varieties are known—namely, the criollas, which are red-skinned and orange-coloured inside, and the ordinary white potatoes. In 1865 the potato disease, which was unknown till that year, attacked the crops, and they have decreased very much in quantity since then. It is worthy of remark that the greater the altitude at which potatoes are planted (they are sometimes planted at a height of above 9000 feet on the mountains) the less tendency is there for the disease to break out, and at the greatest altitudes the disease is almost, if not quite, unknown. With regard to the cinchona industry, the Consul reports that in 1884 the Government of the Republic passed a law for the purpose of promoting the plantation of cinchona, india-rubber, and eucalyptus trees, and the President was authorized to award valuable prizes to the most successful growers of cinchona trees. The trees to be planted were to be of four species, *C. ledgeriana*, *C. officinalis*, *C. lancifolia*, and *C. pitayensis*, but, though the distribution of trees was free, the law has remained a dead letter; no new plantations have been made under its provisions.

A NEW series of experiments upon the vapour-density of aluminium chloride have been made by Profs. Nilson and Pettersson, with the view of deciding the somewhat vexed question of the valency of aluminium. Former experiments of the Swedish chemists led them to the conclusion that aluminium chloride does not become completely vaporized until a temperature of about 800° C. is attained, when the density of the vapour corresponds to the formula $AlCl_3$, this value (4·6) remaining constant until over 1000° C. On the other hand, Messrs. Friedel and Crafts, employing the method of Dumas, found that between 218° and 433° C. the density remains constant at a value (9·2) corresponding to the formula Al_2Cl_6. In order to render their experiments as unimpeachable as possible, Profs. Nilson and Pettersson have made their redeterminations at the lower temperatures by Pettersson and Ekstrand's modification of Dumas method, and have also been enabled by taking advantage of recent improvements in the construction of the Perrot furnace, to extend their observations to a white heat of 1600° C. Taking the higher temperature determinations by Victor Meyer's method first, the platinum apparatus used in the former experiments was discarded for glass and porcelain, as it has been shown that heated platinum has a slightly injurious effect upon the stability of aluminium chloride. Using glass apparatus heated in sulphur vapour (440° C.) the density was found to be 7·5. Heated still further in vapour of phosphorus pentasulphide (518°) the density diminished to 7·16. In stannous chloride vapour at 606° it became reduced to 5·34. The former results with the platinum apparatus at temperatures from 800° to 1000° showed that the density remains constant at about 4·6, corresponding to $AlCl_3$. Using the new Perrot furnace and a porcelain apparatus at 1400°, the density is still found to be not much reduced, 4·26; and at

1600°, the highest temperature attained, the value 4·08 was obtained. It therefore appears that for 600° over 1000° a very small amount of dissociation occurs, probably owing to the influence of a small platinum tube in which the chloride was introduced, as a minute quantity of an alloy of aluminium and platinum was afterwards found. Hence the molecules of $AlCl_3$ must be remarkably stable. The first of the experiments by the method of Dumas was conducted at the temperature of boiling nitrobenzene, 209°; at this temperature the density was 9·9. At the temperature of boiling eugenol, 250°, 9·62. At 301°, in vapour of diphenylamine, 9·55. In mercury vapour, at 357°, 9·34. In volatilized antimony tri-iodide, at 401°, 9·02; while at the temperature of boiling sulphur, the density, according to this method, had diminished to 8·79. From these results the Swedish experimenters conclude that the vapour-density of aluminium chloride decreases continuously and almost regularly up to 800°, when it becomes practically constant for four or five hundred degrees of temperature, and that although the value 9·2 is found somewhere between 200° and 400°, yet this value does not remain constant for a sufficient interval of temperature to enable us to assert the existence of molecules of the composition Al_2Cl_6.

THE additions to the Zoological Society's Gardens during the past week include two Common Marmosets (*Hapale jacchus*) from South-East Brazil, presented by Mr. Stanley Gibson; a Canadian Beaver (*Castor canadensis*) from North America, presented by Mr. J. R. Politzer; a Palm Squirrel (*Sciurus palmarum*) from India, presented by Mr. W. Tweedie; a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mrs. E. Reeves; a Centipede, presented by Dr. C. H. Bousfield; a Rhesus Monkey (*Macacus rhesus*) from India, two Black-headed Lemurs (*Lemur brunneus*) from Madagascar, two Spur-winged Geese (*Plectropterus gambensis*) from West Africa, a Red and Yellow Macaw (*Ara chloroptera*) from South America, deposited; two Black Storks (*Ciconia nigra*), European, two Mantchurian Crossoptilons (*Crossoptilon mantchuricum*) from Northern China, purchased; a Puma (*Felis concolor*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OBSERVATORIES.—A list of the astronomical observatories of the world, by George H. Boehmer, has just been reprinted from the Smithsonian Report for 1886 (Government Printing Office, Washington, 1889). The work is the outcome of the preliminary account published by Prof. Holden, in 1879, a large amount of material having since been collected by correspondence. The various observatories are arranged under two heads—(1) American, (2) foreign—an alphabetical arrangement being adopted in each case. References are made to 78 American and upwards of 200 foreign observatories, including private observatories. In many cases the particulars are incomplete, but it is hoped that the publication will induce the directors of observatories to communicate to the author any further accounts and corrections which they may deem desirable. Latitudes and longitudes are given in nearly every case, and also a list of past and present directors. Descriptions of the more important observatories and their instrumental equipments are given.

A SPECTROSCOPIC SURVEY OF SOUTHERN STARS.—In a private letter, Mr. R. L. J. Ellery, F.R.S., writes:—"We have been making a spectroscopic *reconnaissance* of southern stars with a 'Maclean' spectroscope on our 8-inch refractor as a kind of 'jackal' list for the great reflector, with which we intend to make a systematic spectroscopic survey of stars between 40° S. and the South Pole. I am sending to the Royal Astronomical Society the first list of 100 stars." This is a most important step, and fills a gap which has been a disgrace to southern science.

THE ASTRO-PHOTOGRAPHIC CONFERENCE.—The *Comptes rendus*, containing the full proceedings of the above Congress, which met at Paris during the past month, have not yet been received. The following, however, are some of the points decided by the Permanent Committee:—

The centre of the plate is to be pointed not more than 5″ distant from the selected point in the heavens, the size of the plate to be 160 millimetres square. The size of the field adopted was 2° square, whilst the *réseau* is to be 130 millimetres square, with lines 5 millimetres apart.

The amount of overlapping decided upon was 5′. Vogel has undertaken the construction and verification of the *réseau*. The distribution of the work among the co-operating Observatories has been completed, and to Greenwich is allotted that from Declination +48 to +40.

Plate glass only must be used for the plates; the chemical formula, however, is left open. The sensitiveness for the Chart and for the Catalogue is to be the same. *Réseau* to be used in both series.

A series of standard plates will be prepared by the Paris Observatory, and the time of exposure must be adjusted so as to compare properly with these standards. There will be one or more *bureaus* established for such Observatories as cannot measure their own plates.

INTERNATIONAL CONGRESS ON CELESTIAL PHOTOGRAPHY.—There was a preliminary meeting of this Congress at Meudon on September 20, to consider the programme that had been drawn up by the Provisional Committee. A few slight alterations were made in the original scheme, but the details of the work were not entered into. It was, however, decided that the greatest latitude should be allowed in the choice of instruments, and that each observer should employ that instrument to which he was accustomed, having no regard to uniformity.

In order to indicate the spectroscopic work included in the programme, a change in the style of the Congress was agreed to. It is henceforth to be the "International Congress on Celestial Photography and Spectroscopy."

A LARGE detailed drawing of the Milky Way—the result of five years' labour—is now on view at the rooms of the Royal Astronomical Society, Burlington House. An explanatory note will be read at the next (November) meeting of the Society.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 OCTOBER 20–26.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on October 20

Sun rises, 6h. 35m.; souths, 11h. 44m. 47·5s.; daily decrease of southing, 9·8s.; sets, 16h. 55m.: right asc. on meridian, 13h. 41·3m.; decl. 10° 31′ S. Sidereal Time at Sunset, 18h. 52m.

Moon (New on October 24, 14h.) rises, 1h. 3m.; souths, 8h. 35m.; sets, 15h. 52m.: right asc. on meridian, 10h. 31·5m.; decl. 13° 56′ N.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	5 42	11 10	16 38	13 6·8	7 1 S.
Venus ...	3 46	10 0	16 14	11 56·2	2 4 N.
Mars ...	2 42	9 18	15 54	11 13·7	6 26 N.
Jupiter ...	12 24	16 16	20 8	18 13·4	23 30 S.
Saturn ...	1 12	8 19	15 26	10 15 1	12 14 N.
Uranus...	6 7	11 28	16 49	13 24·8	8 18 S.
Neptune..	18 26*	2 15	10 4	4 9·7	19 19 N.

* Indicates that the rising is that of the preceding evening.

Oct.	h.	
20	1	Saturn in conjunction with and 3° 1′ south of the Moon.
21	6	Mars in conjunction with and 3° 43′ south of the Moon.
22	6	Venus in conjunction with and 3° 48′ south of the Moon.
24	11	Mercury stationary.
24	19	Mercury at least distance from the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	Oct. 20,	2 25	*m*
			,, 25,	2 4	*m*
λ Tauri	3 54·5	12 11 N.	,, 20,	20 28	*m*
			,, 24,	19 20	*m*
ζ Geminorum	6 57·5	20 44 N.	,, 24,	2 0	*M*
U Coronæ	15 13·7	32 3 N.	,, 24,	20 48	*m*
R Lyræ	18 52·0	43 48 N.	,, 21,		*M*
U Aquilæ	19 23·4	7 16 S.	,, 26,	20 0	*M*
η Aquilæ	19 46·8	0 43 N.	,, 21,	2 0	*M*
			,, 25,	21 0	*m*
S Sagittæ	19 51·0	16 20 N.	,, 26,	23 0	*m*
R Sagittæ	20 9·0	16 23 N.	,, 25,		*m*
X Cygni	20 39·0	35 11 N.	,, 20,	2 0	*m*
δ Cephei	22 25·1	57 51 N.	,, 23.	21 0	*M*
U Cassiopeiæ	23 52·8	50 46 N.	,, 26,		*M*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near β Tauri	78°	32° N.	Swift.
,, ν Orionis	90	15 N.	The *Orionids.*
,, δ Geminorum	106	22 N.	Swift.
,, σ Ursæ Majoris	135	68 N.	Swift.

GEOGRAPHICAL NOTES.

DR. MOHN contributes to the *Scottish Geographical Magazine* a useful summary of our knowledge of the Barents Sea, between Spitzbergen and Novaya Zemlya. The depths of the Barents Sea contrast in a marked degree with those of the Norwegian and Greenland Seas. Between Jan Mayen and Norway, and between Greenland and Spitzbergen, there are depths of upwards of 2000 fathoms, but the bottom of the Barents Sea is found at depths under 300 fathoms. The transition from the great depths in the western part of the Northern Ocean to the shallows of the Barents Sea is marked by an imaginary line drawn between Western Spitzbergen and Tromsö. Here is a submarine plateau, having on its western wall a steep declivity towards the depths of the Northern Ocean, and on its eastern wall a relatively flat sea-bottom rising slowly towards the coasts of Norway, Russia, Novaya Zemlya, and Spitzbergen, and continuing towards the north-east, with only 100 fathoms of water, to between Spitzbergen and Novaya Zemlya. The adjacent Siberian Sea is also characterized by slight depths. The Barents Sea is therefore deepest in its western part. A depreesion of upwards of 200 fathoms in depth projects from here into the middle of the sea eastwards as far as the longitude of Vardö, the part of the bottom lying further east having depths varying between 200 and 100 fathoms, but more generally averaging the latter. The 100-fathom line runs very near the Norwegian coast; here the bottom consequently descends rather quickly from the coast-line. But from Kola, on the Murman coast, the 100-fathom line stretches direct to Novaya Zenlya, and continues in a sinuous direction to the north of this twin island. Further on we find it again in higher latitudes. It incloses Bear Island, and reaches the banks of Western Spitzbergen. On the eastern plain of the Barents Sea, where the depths are mostly a little over 100 fathoms, are found some slight elevations and depressions; the form of the sea-bottom is slightly undulating. As regards the material deposited on the bottom of the Barents Sea, we have acquired some knowledge from the researches of the Norwegian North Atlantic Expedition. The specimens consist of a peculiar sort of clay, different in description from that lying on the bottom of the deep Northern Ocean. Its chief constituent is silica (quartz); it is very poor in carbonate of lime, and is characterized by the existence in it of the shells of a small animal belonging to the Foraminifera, from which our zoologists have given it the name of the Rhabdammina clay. Its colour is dark green. It is probable that this material is derived from the quartz rocks of the surrounding countries, which, by means of the rivers, tides, currents, and drift-ice, have been spread over the sea-bottom. The salinity of the water of Barents Sea is slightly lower than that of the Norwegian Sea, particularly at the surface. The temperature of the water in the Barents Sea exhibits some contrast in its southern and its northern part. The mean annual temperature of the surface is 5° C. at the North Cape, 4° on the Murman coast, from 2° to 1° C. on the west coast of Novaya Zemlya, and 1° C. at Bear Island. In the month of August—the warmest for surface temperatures—the normal temperature of the sea is 9° C. at Söröen (Hammerfest), 8° to 6° and lower on the Murman coast, 5° to 1° at Novaya Zemlya, 2° at Bear Island, and 1° at the South Cape of Spitzhergen. In March—the coldest month for surface temperatures—the temperature of the sea is 2°·4 C. at the North Cape, 1°·4 at Vardö, 0° to − 2° at Novaya Zemlya, a little above 0° at Bear Island, and 1° at the South Cape of Spitzbergen. For the whole year as well as for the warmest and the coldest months, the surface water is consequently warmest at the coast of Finmarken, and coldest in the sea between Novaya Zemlya and Spitzbergen. At the depth of 100 fathoms we have 4° C. off Hammerfest, 3° off the Tana Fjord, 2° off the Fisher Peninsula (Rybatschi Ostrow), 1° off Kola, and 0° along a line running south to north from the 70th to the 75th parallels of latitude, and east to west along the last-named parallel. Similar curves show the other isotherms for 1° to 4°. In the above-named bay, bordered by the 200-fathom line, are found temperatures of from 1° to 3° above zero. At the sea-bottom, irrespective of its depth, the temperature is distributed in the following degrees. Off and near the coast of Finmarken it is upwards of 4° from Vardö to off Hammerfest, and 5° further west. From here the temperature decreases towards the east and towards the north. The current runs in the Barents Sea as a rule along the coast of Finmarken and the Murman coast eastwards, in the eastern part of the sea northwards, and in the northern part, between Novaya Zemlya and Spitzbergen, westward. Along the east coast of Spitzbergen the current sets southwards. The warm Atlantic current, a branch of the Gulf Stream (this name being taken in its widest sense) runs along the coast of Finmarken, curves on leaving the Murman coast towards the north, and turns then to the west towards Bear Island. It fills the sea down to the bottom with its temperate water. This is warmest in the southern branch running eastwards; and it becomes by and by, further on, cooled down by the neighbouring ice-cold water with which it mixes, and which from the northern regions is driven southwards and westwards. The surface of the sea between Spitzbergen and Novaya Zemlya is always covered with drifting ice. The larger animals in the sea being the objects of capture, live on smaller animals. The development and presence of these small organisms is greatly dependent on the temperature of the water. But their presence in a certain place, and to a certain time, depends upon the oceanic currents, these being as a rule so strong, and the locomotive powers of the small animals so small, that these must follow the movements of the currents. The animals living at or on the bottom get their food brought to them by means of the currents.

DR. JULIUS RÖLL, of Darmstadt, in the course of a mission of botanical exploration in the north-west of America, made an ascent in June 1888 of a summit in the Cascade Mountains, hitherto unnamed on our maps. The peak in question is situated under long. 121° 15′ W., and lat. 47° 22′ N., between two small lakes, and about 20 miles north of Easton on the Northern Pacific Railroad. The following is taken from a short account of his excursion contributed by Dr. Röll to the current number of *Petermann's Mitteilungen*. On June 19, in company with Herr Purpus, he made his way through the primæval forest, and over rising ground to the foot of the mountain, pitching his tent at an altitude of 5500 feet. The next morning the actual summit was ascended. It is composed of melaphyr, and many pieces of agate and rock crystal were found. The steep slopes are overgrown with ceanothus bushes, maples, and pines, between which bloom yellowish-red lilies (*Lilium philadelphicum*), and species of dark-red pentstemons. Three successive summits were climbed. The highest was estimated at 7500 feet; unfortunately the exact altitude could not be ascertained, as the traveller's barometer had become useless. The rocky crest of the mountain is covered with the *Selaginella rupestris*, pentstemons, phlox, pedicularis, several saxifrages, and some low umbelliferous plants, &c. Traces of bears, mooses, and mountain sheep were observed. The following day another ascent was made, and a magnificent view of the snow-covered Mount Tacoma obtained. Some weeks later, finding that the peak he had ascended was unnamed, Dr. Röll designated it "Mount Rigi," from the resemblance to the Swiss mountain of that name.

THE question of the influence of wind and rain in valley formation is discussed by Herr Rucktäschel in a short memoir contributed to the current number of *Petermann's Mitteilungen*, abstracted in the Proceedings of the Royal Geographical Society. The author, who has been pursuing his studies in Saxony and elsewhere, ascribes the "one-sidedness" which is observable in so many of the river valleys of Saxony to the action of rainy winds, in the absence of considerations arising from the configuration or composition of the soil. It has been observed that, in the case of most streams in this region flowing through soft sandstone, conglomerate, and diluvial soils, the east, north-east, or south-east bank presents a steep slope, while the opposite shore is flat. The cause is, according to Herr Rucktäschel, to be found in the action of the prevailing south-west, west, and north-west winds, which, heavily charged with rain, precipitate themselves almost at right angles upon the eastern sloping bank of a stream, washing away the soil in much greater quantity than from the western bank, and thus producing the one-sidedness referred to. Similar phenomena have been observed in some of the river valleys of Prussia and Bavaria. The author lays down the following conditions as necessary for the production of these effects by the westerly rain winds:- (1) the soil must be composed of some loose or soft substance, (2) the valley must be eroded to a certain depth, (3) the volume of water in the stream must not be too great in proportion to that washed down the banks. For these reasons the phenomena can occur, as a rule, only along the smaller rivers, a large river; by the force of its own current, shapes its banks, and the influence of the prevailing rain winds is not so noticeable. Herr Rucktäschel visited England last summer to carry out researches there, but was unable to find any river-valleys suited for his purpose.

IT is reported from Hong Kong that the expedition of Mr. Rosset in the as yet unexplored districts of Annam, Cochin China, Cambodia, Siam, and the Laos States has been concluded. Much danger and many difficulties were encountered, but the result has been excellent, and Mr. Rosset will take back with him to Europe a valuable collection illustrative of the ethnology of the regions he has traversed. The journey was divided into three sections. The first comprised the Mekong River, the Chane and Bang-Came Rivers, to Stung-treng, in Siam, 104° to 106° long. and 13° to 14° lat. In this section the tribes of the Brouns or Bruns, the Kongs, and the Bennongs, were visited and studied. The second section of the journey as projected was from the mouth of the River Dongnai in Cochin China up to the frontier, covering the country between 104° and 106° long., and 11° and 12° lat., the special object of study being the ethnology of the Mois tribes. It was found, however, that the route was impracticable, the heavy rains and thickness of the jungle preventing the progress of the caravan, and the expedition was obliged to make a detour into the mountains of Binthuan. The third section of the journey again followed the Mekong River to Kratse, from thence branching east and north-east to the coast of Annam. Approaching Bung U the expedition followed a north-easterly direction to 13° lat. About 25 kilometres south-east of Kratse the River Pree Sé was passed, and the same river was crossed three times in the journey north-east to the coast; also a tributary river called the Sala. In this section the tribes of the Bennongs, Sliengs, Nhongs, and Ahongs were studied.

THE TEACHING OF SCIENCE.[1]

IN a Report presented to the Bath meeting the Committee gave an account of the replies they had received to a letter addressed to the head masters of schools in which elementary chemistry is taught. In this letter the Committee had asked for a report on the chemical teaching, and also for a statement as to the methods which had been found to render the teaching most effective as mental training. In commenting on these replies the Committee pointed out that the evidence which had been collected was conclusive in showing that much of the teaching of elementary chemistry is far from satisfactory, and needs to be considerably modified if it is to effect that valuable mental discipline which science teaching can afford.

[1] Report of the Committee, consisting of Prof. H. E. Armstrong, Prof. W. R. Dunstan (Secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (Chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the present methods of teaching Chemistry.

The Committee are convinced that the high educational value of instruction in physical science has never been exhibited to its full advantage in most of our educational institutions. Nevertheless there exists already a considerable body of experience which proves that there is no more effective and attractive method of training the logical faculties than that which is afforded by a properly arranged course of instruction in physical science; by no other means are the powers of accurately ascertaining facts, and of drawing correct inferences from them, so surely developed as they are by the study of this subject.

Since the last meeting the Committee have been actively engaged in discussing the lines which a course of elementary instruction in chemistry should follow. The Committee were the more inclined to offer suggestions of their own, since they had learnt from the replies made to their letter of last year, by teachers in many of our well-known schools, that not only is the necessity for the adoption of improved methods fully recognized, but that teachers are anxious to receive advice and assistance in introducing them.

It cannot be too strongly insisted that elementary physical science should be taught from the first as a branch of mental education, and not mainly as useful knowledge. It is a subject, which when taught with this object in view, is capable of developing mental qualities that are not aroused, and indeed are frequently deadened, by the exclusive study of languages, history, and mathematics. In order that the study of physical science may effect this mental education, it is necessary that it should be employed to illustrate the scientific method of investigating Nature, by means of observation, experiment, and reasoning with the aid of hypothesis; the learners should be put in the attitude of discoverers, and should themselves be made to perform many of the experiments. The lessons ought to have reference to subjects which can be readily understood by children, and illustrations should be selected from objects and operations that are familiar to them in every-day life. Chemistry is particularly well adapted for affording this kind of instruction, and the Committee are of opinion that a course which is mainly chemical will be most useful in developing logical habits of thought.

Chemical inquiry involves, however, the use of various physical processes, and these are themselves of great value from the point of view from which the instruction is being given. It is also of great importance that the learners should become acquainted with the characteristic instrument of physical science, viz. measurement, and therefore quantitative processes should be largely made use of.

Having agreed as to the general principles on which a scheme of elementary instruction in chemistry should depend, the Committee gladly accepted the offer of Prof. Armstrong to draw up an account of such a scheme in sufficient detail to serve as a guide to those who have to provide such teaching. Without pledging themselves to accept all its details, the Committee consider that the scheme which Prof. Armstrong has prepared is in general accordance with their views as to what should constitute a course of elementary instruction in physical science.

With regard to the manner in which the scheme should be carried out, the Committee wish to lay stress on the following points. In order that the plan shall produce its full educational effect, the instruction should be commenced at an early age, and be extended to every child in the school. They do not desire to bring forward physical science as a substitute for any of the other principal subjects of study, but they ask that like these subjects it should be looked upon everywhere as a necessary part of education, and that it should receive a due share of the time devoted to school work. It is well known that at present science-teaching does not generally receive as much time and attention as is given to other studies. This was made clear in the Report of the Committee last year. It will be necessary to allot more time to the subject, and to employ a greater number of teachers. A teacher should not be required to give practical instruction to more than from fifteen to twenty pupils at one time, although the classes at lectures and demonstrations might be somewhat larger.

While the scheme now proposed may involve the employment of a larger number of teachers of natural science, on the other hand fittings and apparatus of the simplest description are all that will be absolutely needed, and the cost of maintenance will be relatively small.

The Committee are aware that the course of instruction now suggested is not in conformity with the present requirements of examining bodies. Its general adoption must therefore depend on their co-operation.

Suggestions for a Course of Elementary Instruction in Physical Science, drawn up by Prof. Armstrong.

Although the Committee is ostensibly charged to report as to methods of teaching *chemistry*, chemistry pure and simple is not what is required in schools generally, and therefore the Committee must be prepared to take into consideration and make recommendations as to a course of instruction preliminary to the natural science course proper, which in their opinion affords the most suitable and efficient preparation for later natural science studies.

After the most careful consideration of the question during at least ten years past, and after long holding the opinion that chemistry as usually understood is not the most suitable science subject for school purposes, I am now of opinion that a course which is mainly chemical is not only the best but also the only one possible if we are to secure all the objects aimed at in introducing science teaching into schools. Those objects are essentially: to train boys and girls to use their brains; to train their intelligence; to make them observing and reasoning beings, accurate observers, and accurate thinkers; to teach them to experiment, and that, too, always with an object—more frequently than not with what may be termed a logical object—not for mere descriptive purposes; to gradually inculcate the power of "doing," on which Charles Kingsley has laid so much stress, and which undoubtedly is the main factor of success in life. It can scarcely be gainsaid that through chemistry more than through any other branch of natural science it is possible to give precisely that kind of "practical" training so requisite at the present day, because the student is able to ascertain *by experiment* what are the exact facts, and thus to arrive independently at an explanation, whereas in the case of other sciences more often than not the explanation of necessity has to be given by the teacher.

Chemistry as usually taught loses greatly in educational value because pupils are told, more often than not, that "so and so is the case," instead of being taught *how it has been found out* that such is the case; indeed, that which has to be proved is usually taken for granted. Practical chemistry has hitherto, as a rule, been interpreted to mean the preparation of a few gases, &c., and the analysis of simple salts. Much useful information may be and is occasionally imparted during the performance of exercises of this kind, but the tendency undoubtedly is for analysis to degenerate into a mechanical drill, and, looking at the question from the practical point of view, and considering what is the general outcome of such teaching, probably we are bound to agree that the results thus far obtained are usually unsatisfactory. The difficulty, however, is to devise a course sufficiently simple both in conception and when carried into practice the cost of which is not too great; but with respect to this item of cost the Committee has to make clear to parents and teachers the claim of natural science to a fair and proportionate share of the total expenditure, which certainly has never yet been granted to it. By the introduction of such studies into the school course, a set of faculties are trained which it is all-important to develop, but which hitherto have been allowed to remain dormant, if not to atrophy, through neglect, and which, it is admitted by all competent authorities, cannot possibly be developed by any amount of attention paid to literary and mathematical studies. It is often not sufficiently clearly stated or understood that the advocates of natural science studies have no desire to displace any of the traditional subjects from the school course, and that all that they ask for is a fair share of the child's time, attention, and brains—a share proportionate to the effect which such studies can demonstrably produce in developing the mental faculties of the individual: that, in fact, natural science claims to co-operate and in no sense puts in an appearance as a rival.

STAGE I.—*Lessons on common and familiar objects.*

The first stage of instruction must be one of simple object-lessons, but these should have an intimate relation to the child's surroundings, and should be made the pegs on which to hang many a tale. Probably the most satisfactory and practical mode of commencing is to get children to draw up lists of familiar and common objects under various heads, such as

Natural objects.

Things used in building construction.

Things from which household furniture is made or which are in daily use.

Things used as clothing.

Food materials.

The children should be induced to describe these from observation as far as possible; to classify them according to their origin into mineral and animal and vegetable or organic; and occasion should be taken at this stage to give by means of reading lessons and demonstrations as much information as possible about the different things, their origin, how made, and their uses. It is obvious that in this way a great deal of geography and natural history (*Naturkunde*) might be taught in an attractive manner. Geikie's "Science Primer on Physical Geography" is the type of book which may be worked through with great advantage at this stage.

STAGE II.—*Lessons in measurement.*

This stage should be entered upon as soon as children have learnt the simple rules of arithmetic, and are able to add, subtract, multiply, and divide, and to use decimals.

Lineal measurements may be first made, using both an English foot-rule with the inch subdivided in various ways and a metric rule subdivided into millimetres. In this way the relation of the two scales is soon insensibly learnt.

Measurements of rectangular figures and the calculation of their areas may then be made.

After this the use of the balance may be taught, and the relation between the English and French systems may be learnt by weighing the same objects with the two kinds of weights. Use may then be made of the balance in determining the areas of irregular figures by cutting out rectangular and irregular figures from the same cardboard or thin sheet metal, and weighing these, &c.

Solid figures are next studied: a number of cubes made from the same wood having been measured, their volumes are then calculated, and the results thus obtained are compared with those which are obtained on weighing the cubes. The dimensions and weights of cubes made from different woods or other materials are then ascertained, and thus it is observed that different materials differ in *density*. The study of the *relative density* of things generally is then entered upon. The ordinary method is easily learnt and used by children, a suitable bottle being provided by filing a nick down the stopper of a common two-ounce narrow-mouth bottle; it may then be shown that the same results are obtained by the hydrostatic method of weighing in air and water, and it is not difficult to lead children to understand this latter method after they have determined the heights of balancing columns of liquids, such as turpentine, water and saturated brine, of which they have previously ascertained the relative density. These hydrostatic experiments are of value at a later stage in considering the effects of atmospheric pressure.

By determining the dimensions of a cube and the weight of the water which it will displace, an opportunity is afforded to point out that if the results are expressed in cubic centimetres and grammes respectively there is a practical agreement between the numbers, and hence, to explain the origin of the metric system of weights and the relationship between its measures and weights; the irrationality of the Ehglish system may then be explained.

The relative densities of a large number of common substances having being ascertained, the results may be tabulated and then the value of the data as criteria may be insisted on; as an illustration of their value, quartz, flint, sand, and gravel pebbles may be selected. The children having determined their relative densities, the agreement between the results may be pointed out and the identity of the material explained. By drawing perpendiculars corresponding in height to the densities of various substances, a graphic representation is obtained which serves to bring out the value of the graphic method of representation.

A very valuable exercise to introduce at this stage is based on the well-known fact that in certain conditions of the atmosphere things appear moist; a muslin bag full of seaweed may be hung up under cover but freely exposed, and may then be weighed daily at a given time; simultaneously the state of the weather, direction of the wind, the height of the barometer, and the wet and dry bulb thermometer may be noted; on tabulating the results, and especially if the graphic method be employed, the variations and their relationship will be noticeable.

The thermometer, having thus become a familiar instrument, may be used to examine melting ice and boiling water; the construction of both the Centigrade and Fahrenheit thermometer may then be explained, and the effect of heat on bodies made clear. The density of ice and of water at various temperatures may then be determined, a Sprengel tube—which is easily made—being used for warm water; the bursting of pipes in winter, the formation of ice on the surface of water, &c., may then be explained. Afterwards simple determinations of the heat capacity of a few metals, &c., and of the latent heat of water and steam, may be made in accordance with the directions given in a book such as Worthington's "Practical Physics."

STAGE III.—*Studies of the effect of heat on things generally; of their behaviour when burnt.*

As it is a matter of common observation that heat alters most things, the effects of heat on things generally should be studied; in the first instance qualitatively, but subsequently, and as early as possible, quantitatively. Bits of the common metals may be heated in the bowl of an ordinary clay pipe plunged into a clear place in any ordinary fire, or in such a pipe or a small iron spoon over a gas flame. The difference in fusibility is at once apparent, and in the case of metals like iron and copper it is noticeable that although fusion does not take place, a superficial change is produced; the gradual formation of a skin on the surface of fused lead and tin is also easily perceived. Observations like this become of great importance at a later stage, and indeed serve to suggest further experiments: this is a point of special importance, and from the beginning of this stage great attention should be paid to inculcating habits of correct observation; the effect should first be recorded by the pupil, the notes should then be discussed and their incompleteness pointed out, and they should afterwards be re-written. The fusibility of substances which are not affected when heated in the tobacco pipe may be tested by heating them with a Fletcher gas blow-pipe on charcoal; and by heating little bits of wire or foil in such a flame it is easy for children to discover the changes which metals undergo when burnt, especially in cases such as that of zinc or copper or iron.

The further study of the effects of heat should be quantitative, and may well commence with water. It being observed that water disappears on heating, water may be put into a clock glass or glass dish placed on a water bath (small saucepan); it evaporates, and it is then observed that something is left. A known quantity of water by weight or volume is therefore evaporated and the residue weighed. This leads to the discovery that water contains something in solution. The question then naturally arises, What about the water that escapes? so the steam is condensed and the distilled water evaporated. The conception of pure water is thus acquired. An experiment or two on dissolution—using salt and sugar—may then be introduced, a water oven or even an air oven (a small Fletcher oven) kept at a known temperature being used, and the residue dried until the weight is constant. Rain and sea-water may next be examined; the results afford an opportunity of explaining the origin of rain and of accounting for the presence of such a large quantity of dissolved matter in sea-water. Then the various common food materials may be systematically studied, commencing with milk; they should first be dried in the oven, then carbonized and the amount of char determined, then burnt and the percentage of ashes determined. A small platinum dish, 15 to 20 grammes in weight, is required for these experiments, and a gas muffle furnace is of the greatest use in burning the char and in oxidizing metals. In addition to the discipline afforded by such experiments a large amount of valuable information is acquired, and the all-important fact is established that food materials generally are combustible substances. Afterwards mineral substances are examined in a similar manner, such as sand, clay, chalk, sulphur, &c., and then metals such as lead, copper, tin, and iron may be studied; their increase in weight is in striking contrast to the inalterability of substances like sand and salt, and the destruction of vegetable and animal substances. Chalk, from which lime is made by burning, is found to occupy a middle position, losing somewhat in weight when strongly heated. The exceptional behaviour of coal among mineral substances, and of salt among food materials, is shown to be capable of explanation, inasmuch as coal is in reality a vegetable and salt a mineral substance; but sulphur remains an instane of exceptional behaviour requiring explanation. It is not exceptional in being combustible, as metals like magnesium and zinc are combustible, but in affording no visible product. The smell of burning sulphur, however, serves to suggest that perhaps, after all, there is a something formed which is an invisible substance possessed of an odour, and then follows quite naturally the suggestion that perhaps in other cases where no visible or perceptible product is obtained—as on burning charcoal, for instance—there may nevertheless be a product. Whereas, therefore, in Stage I. the pupil will have learnt to appreciate the existence of a great variety of substances, and will have gained the power of describing their outward appearance more or less fully; and in Stage II. having learnt how to measure and weigh, will acquire the habit of determining by measurement certain properties of substances, and will thus be in a position to express in exact terms the kind of differences observed; in Stage III. the pupil will be led to see that profound changes take place on burning substances, and that these changes involve something more than the destruction of the things burnt. The foundation is thus laid for the study of change, *i.e.* chemical studies proper.

STAGE IV.—*The problem stage.*

Many of the changes observed in the course of the experiments made in Stage III. might be examined and their nature determined, but the best to take first is a very familiar case, that of the rusting of iron.

PROBLEM I. *To determine what happens when iron rusts.*—The pupil *must* be led in the first instance to realize that a problem is to be solved, and that the detective's method must be adopted and a *clue* sought for. It is a familiar observation that iron rusts, especially when wet; what happens to the iron, why does it rust, is the iron alone concerned in the change? No information can be gained by looking at it—perhaps the balance which has brought to light so much in Stage III. may be of service, so the iron is allowed to rust in such a manner that any change in weight can be observed. A few grammes of iron filings or borings are put on to a weighed saucer or clock glass along with a bit of stiff brass or copper wire to be used as a stirrer; the iron is weighed, then moistened and exposed under a paper cover to keep off dust, preferably in a warm place; it is kept moist and occasionally stirred. After a few days it is dried in the oven and then weighed. The weight is greater. *Something from somewhere has been added to the iron.* Thus the clue is gained. Where did this something come from? The fact that when a tumbler, for instance, is plunged mouth downwards into water the water does not enter, and that on gradually tilting the tumbler to one side something escapes—viz. air—at once affords a demonstration of the presence of air in the space around us. The iron rusted in this air, but was kept moist, so it may have taken up the something from either the air or the water. To ascertain whether the air takes part in the rusting, some iron borings are tied up in a bit of muslin and the bag is hung from a wire stand placed in a (jam) pot full of water and a so-called empty (pickle) bottle, which in reality is full of air, is inverted over the iron; in the course of a few hours, as the iron rusts, the water is observed to rise until it occupies about one-fifth of the jar (determined by measuring or weighing the water); the something added to the iron during rusting appears therefore to come from the air, and the all-important fact is thus discovered that the rusting is a change in which not the iron alone, but also the air, is concerned. The experiment is several times repeated, fresh iron being used with the same air and the same iron put in succession into fresh portions of air, but the same result is always obtained: whence it follows that whatever it is in the air which takes part in the rusting, the air as a whole is not active. The changes previously observed to take place when iron, copper, lead, zinc, &c., were heated in air, are then recalled; as the metals were found to increase in weight, it would appear probable that in these cases of change also the air was concerned.

These results at once suggest the question, What is air? So much having been learnt by studying the change which iron undergoes in rusting, other changes which happen in air therefore are next studied.

PROBLEM II. *To determine the nature of the changes which take place on burning substances in air.*—The use of phosphorus is introduced by reference to a match. Phosphorus is then burnt under a bell jar over water and the result noted: the disappearance of some of the air again shows that the air is concerned. The fact that phosphorus smokes when taken out of the water in which it is always kept suggests that some change is going on, so a stick of phosphorus is exposed in air as in the previous experiment with iron: soon one-fifth has disappeared, and the phosphorus then ceases to smoke. The *quantitative* similarity of the two results suggests that iron and phosphorus behave alike towards air, and *vice versâ*, and serves to confirm the idea that some constituent of the air present only to the extent of about one-fifth is active. But nothing is to be taken for granted, so iron is exposed in the phosphorus-air residue and phosphorus in the iron-air residue: as no change occurs, there is no room left for doubt. Recalling the experiments in which various metals were burnt in air, in order to determine whether in these cases the same constituent of the air was concerned in the change, air from which the active constituent has been removed by means of phosphorus is passed through a heated tube containing bits of the metals: no change is observed, so it is evident that as a rule, if not always, one and the same constituent of air is concerned. The experiments with iron and phosphorus, although they show that the air is concerned in the changes which are observed to take place, do not afford any information whether or no the water which is also present is concerned in the change. Phosphorus is therefore burnt in a "Florence" flask closed with a rubber stopper: on removing the stopper under water some water enters, and by measuring this and the amount of water which will fill the flask the same result is obtained as in the previous cases. To be certain whether in this case anything enters or escapes from the flask it is weighed before and after the phosphorus is burnt. There is no change in weight. But does nothing escape? Yes, much heat; whence it follows that heat is not material—that, although some of the air disappears, it is merely because it has become affixed to or absorbed by something else. This has been proved in the case of the rusting iron and the burnt metals. To obtain indisputable evidence in the case of the phosphorus this is burnt in a current of air in a tube loosely filled with asbestos to retain the smoke: the weight is found to increase. The observation that the phosphorus ceases to burn after a time suggests the introduction of a burning taper into the residue left by iron, &c.; it is found to be extinguished. Then a candle and subsequently a gas flame may be burnt in a bell jar full of air over water. Reversed combustion may then be demonstrated in order to fully illustrate the reciprocal character of the phenomena. Thus it is ascertained that all ordinary cases of combustion are changes in which the air, and not the air as a whole but a particular constituent, is concerned, and no doubt remains that the same constituent is always active, but active under different conditions; it is realized also that the production of heat is the consequence of the union of the substance burnt with the active substance in air. The experiment of exposing phosphorus in air affords the opportunity of demonstrating the evolution of heat even in a case where no visible combustion occurs, as the phosphorus is always observed to melt. At this stage careful note should be taken of the appearance of the different products of combustion, and of a change such as that which occurs when the product from phosphorus is exposed to the air.

PROBLEM III. *To separate the active from the inactive constituent of air.*—It now has become of importance to get this active constituent of the air by itself, and the question arises whether it cannot be separated from one of the metals or other substances with which it has been found to combine. The pupil is therefore told to collect information about the different substances formed by burning metals, &c.,—whether they can be obtained in sufficient quantity to work with, &c. Iron rust and iron scale are easily obtainable, and so is copper scale; zinc is burnt to produce zinc white, which is used as paint; lead is also burnt on a large scale, and in this case it appears that one or other of two substances is formed—litharge at a high temperature, red lead at a lower temperature. This peculiarity of lead suggests the study of the two products in the hope of discovering the clue to a method. Weighed quantities of the litharge and red lead are heated; it is observed that only the latter changes in appearance and that it loses weight. But what does it lose? It was formed by merely roasting lead in the air, and the something which it loses must therefore have been derived from the air. If the red lead is heated in a tube a gas is given off which is collected and tested—how? With a taper or glowing splinter as it is to be supposed that the gas will support combustion if, as is to be expected, it is the active constituent of air. The *discovery* of the active constituent of air is thus made! If air consist of this gas and that which remains after exposing phosphorus or iron in air, then by adding to such residual air as much of the gas from red lead as was withdrawn, air should be re-obtained; this is found to be the case. The names of the two gases are now *for the first time* stated, and an easy method of preparing oxygen is demonstrated, such as that of heating chlorate, but without any explanation. The conclusion previously arrived at, that probably in all the cases previously studied of changes occurring in air, the oxygen is the active substance, may now be verified by burning or heating in oxygen the substances which had been burnt in air.

So much having been learnt of the chemistry of air, the study of the pressure exercised by air may next be taken up, and the common pump, the force pump, the barometer, and air currents may be discussed and explained. Nowadays the charts given in the daily papers, and the Ben Nevis and glycerine barometer readings quoted in the *Times* make it particularly easy to explain the barometer. The pupils should be led to make barometer curves.

PROBLEM IV. *To determine the composition of chalk.*—The discovery of the *composition* of the air in the course of experiments made with the object of determining the nature of certain changes naturally suggests that the attempt be made to ascertain the composition of other things by studying the changes which they undergo. Chalk is known to give lime when burnt, and experiments made in Stage III. have indicated that chalk loses something when burnt—the idea that an invisible something is given off is especially probable after the experiments with red lead have been made; so it is decided to heat chalk strongly, but before doing this chalk and lime are examined comparatively. Chalk is not observed to be altered by water; on shaking it up with distilled water and evaporating some of the filtered liquid in a weighed dish, very little residue is obtained—so it is established that it is but very slightly soluble in water. Lime is slaked, weighed quantities of lime and water being used; the retention of a considerable amount of water, even after exposing the slaked lime in a drying oven, shows that the slaking involves a definite change in composition—that slaked lime is lime and water. The solubility of the lime is next determined, and found to be considerably greater than that of the chalk. It is found that chalk is but very slightly altered in weight when heated over a gas flame, and that it is only when it is strongly heated that it is converted into lime: so the chalk is strongly heated in an iron tube in a Fletcher blow-pipe furnace, when gas is freely given off. This is tested with a taper, which it extinguishes, so it cannot be oxygen, but may be nitrogen; if it be nitrogen, when mixed with oxygen in the proportion of 1 to 4, it should give air, but this is found not to be the case; so evidently it is a peculiar gas, and may be called chalk gas. If chalk consist of this gas and lime it should be possible to reproduce chalk from them; so the gas is passed through a small weighed tube containing lime, and the tube is found to get heavier. But lime and chalk are so much alike that it is difficult to say that chalk is formed; perhaps dissolved lime will act similarly; the gas is therefore passed into or shaken up with lime water. The precipitate which forms looks like chalk and probably is, but this remains to be decided. The discovery of this behaviour of chalk gas, however, is important as affording a means of again comparing the gas from chalk with nitrogen. In working with lime water it is scarcely possible to avoid noticing that a film forms on its surface; by exposing a quantity of the lime water a considerable amount of the precipitate is obtained; its resemblance to chalk is noted, and the possible presence of chalk gas in air is thus suggested; but in view of the absence of proof of the identity of the precipitates with chalk a decision is reserved. The discovery is made, however, that air contains something besides oxygen and nitrogen.

It being thus established that chalk consists of two things, lime and chalk gas, at this stage it is pointed out how firmly these two constituents hold to each other in the chalk. The absorption of the gas by the lime—its entire disappearance in fact—is commented on. Accurate determinations of the loss of weight on heating crystallized chalk (calc-spar) should at this stage be carried out before the class, if not by the pupils, so that the numbers may be quoted and that it may become impressed on them that the proportions in which the lime and chalk gas are present is constant. Their attention may be recalled to the oxides previously studied, it being pointed out that on inspection these afford no indication that they contain oxygen; that here again the gas entirely loses its individuality on entering into union or combining. That oxides contain their constituents in fixed proportions may be demonstrated experimentally by oxidizing finely-divided copper and determining the increase in weight, lime being used as drying agent. In this way the characteristics of *compounds* are elucidated. Then the comparison may be made with air, and the fact made clear that it behaves as a mere mixture. Still no reference should be made to elements.

PROBLEM V. *To determine what happens when organic substances are burnt.*—The experiments thus far made have shown that phosphorus and a number of metals burn in the air because they combine with the oxygen, forming oxides, heat being given out *as a consequence;* but that chalk when burnt is split up or decomposed into lime and chalk gas, this result being a consequence of the heating alone, the air having nothing to do with it. It remains to ascertain what happens when organic substances are burnt, as these give no visible product beyond a little ashes. As in all cases when vegetable or animal substances are burnt a certain amount of "char" is obtained, which then gradually burns away, charcoal or coke is first studied. It having been discovered that the oxygen in air is the active cause of burning in many cases, it appears probable that the air is concerned in the burning of charcoal, coal, &c. As when once set fire to, these continue to burn, the charcoal is at once heated in oxygen: it burns, but no visible product is formed; it therefore follows that if the charcoal is oxidized the oxide must be an invisible gas. How is this to be tested for? What gases are already known to the pupil? How are these distinguished? Oxygen is excluded. Is it perhaps nitrogen, and is not perhaps the nitrogen in air merely used-up oxygen as it were, produced by the burning of organic substances? Or is it perhaps that gas which was found in the air along with oxygen and nitrogen, and which turned lime water turbid? This last being an easy test to apply is at once tried; the lime water is rendered turbid, and so to leave no doubt a sufficient amount of the gas is prepared and passed into lime water, the precipitate is collected, and the loss it suffers on heating is determined and found to agree with that suffered by the precipitate prepared from chalk gas. Finally, to ascertain whether the product is really heavier than the charcoal burnt, as in the case of the metals previously studied, the charcoal is burnt in oxygen in a tube connected to a flask containing milk of lime with a lime-drying tube attached to it; the tube is weighed before and after burning. Thus the discovery is made that chalk gas is an oxide of carbon, and that chalk consists of at least three things.

It may be objected that to make the experiment in this manner takes too much time; but to this it may be answered that such experiments are precisely of the kind of those made in actual practice, and that they exercise a most important influence in teaching the pupils to take nothing for granted, never to jump at conclusions, and to rest satisfied if they progress surely, however slow the advance may be.

A number of organic substances may now be burnt, and the gas passed into lime water; chalk gas is found in every case to be a product, and hence the presence of a common constituent—carbon—in all is established. In making these experiments the formation of a liquid product is observed, so it is evident that chalk gas is not the only product, or carbon their only constituent.

Food materials generally having been found to contain "carbon," as they are obviously in some way destroyed within the body, and it is known that air is necessary for life, the question arises, what becomes of food, and why is air necessary for life? Is the food, perhaps, in large part "burnt up" within the body, thus accounting for the fact that our bodies are always warm? The characteristic product of combustion of carbonaceous substances is therefore tested for by breathing into lime water. The discovery thus made affords an opportunity for a digression and for explaining how plants derive their carbon from the air.

PROBLEM VI. *To determine what happens when sulphur is burnt.*—From the results of the experiments with carbon, it appears probable that the disappearance of sulphur when burnt is also really due to its conversion into a gaseous oxide, so it is kindled and introduced into oxygen: if it be burnt over water in a bell jar in a spoon passing through the stopper (a rubber cork), the water is seen to rise; if, on the other hand, it be burnt in a dry flask closed by a rubber cork carrying a gauge-tube, as suggested by Hofmann,[1] the volume is seen to be almost unchanged after combustion. It follows, therefore, that the sulphur and oxygen unite and form a soluble product. Sulphur is next burnt in a tube in a current of oxygen, and the gas is passed into water; a solution is thus obtained having the odour of the gas and sour (acid) to the taste. The fact that carbon and sulphur—both non-metals—behave alike in yielding gaseous oxides suggests that a comparison be made of their oxides; so the acid solution is added to lime water; a precipitate is formed, which redissolves on adding more of the sulphur gas solution; on the other hand, on adding the lime water to the acid liquid, this latter after a time loses its characteristic smell. There can be no doubt, therefore, that the sulphur gas does in some way act upon the lime. The experiment is then made of burning the sulphur in a weighed tube containing lime; the weight increases, so that no doubt remains that sulphur, like carbon, forms an oxide when burnt. The discovery that the addition of more of the sulphur oxide leads to the dissolution of the precipitate which it first forms in lime water, suggests trying the effect of excess of the carbon oxide on the lime water precipitate; this is done, and the discovery is made that the precipitate gradually dissolves. The solubility of the new substance may then be determined by passing the gas into water containing chalk in suspension, filtering, and evaporating. This leads to the observation that a precipitate is formed on heating the liquid, and this is soon found to be chalk. An opportunity is thus afforded of explaining the presence of so much "chalk" in water; of demonstrating its removal by boiling and by lime water; and the effect it has on soap.

The observation that the oxides of both carbon and sulphur combine with lime suggests trying whether the one will turn out the other; so the solution of the sulphur oxide is poured on to chalk: effervescence is observed, and on passing the gas into lime water a precipitate is obtained. The production of this effect by the *acid* solution suggests trying common vinegar—a well-known *acid* substance. This also is found to liberate chalk gas, and the discovery of an easy method of preparing chalk gas is thus made. The oxide formed on burning phosphorus, having previously been found to give an acid solution, is tried, and it is found that it also liberates chalk gas. As a good deal of vinegar is found to give very little chalk gas, the question arises, Are there not acids to be bought which will have the same effect and are stronger and cheaper? On inquiry it is found that sulphuric acid or oil of vitriol, muriatic acid or spirits of salts, and nitric acid or aquafortis may be bought, and that these all act on chalk. The behaviour of chalk with acids affords a means of testing the lime water precipitate obtained in working out Problems IV. and V. In this manner the pupil is led to realize that certain agents may very readily produce effects which are only with difficulty produced by heating—that the *chemical agent* may produce very powerful effects. The ready expulsion of the carbon oxide of chalk suggests that other substances not yet studied, such as the metals, when treated with acids may behave in a special manner which will afford information as to their nature. At this point, prior to making the experiments with the acids, an explanation may be given of the names *oil of vitriol, spirits of salts*, and *aquafortis;* the processes by which they are made may be described and illustrated, without, however, any attempt being made to explain them from the chemical point of view. The sulphuric acid should be made from green vitriol, and its behaviour on dilution should be demonstrated as well as its use as a drying agent.

PROBLEM VII. *To determine what happens when metals are heated with acids.*—Iron, zinc, lead, tin, copper, and silver may be taken. On pouring diluted oil of vitriol on to iron or zinc, the metal dissolves with effervescence; the gas is collected, and when tested is found to burn. Thus a new gas is discovered, differing from all which have previously been studied, inasmuch as it is combustible; in order not to interrupt the study of the action of acids on metals, however, its further examination is postponed for a while. Resuming the experiments with metals, lead, tin, copper, and silver are found not to be acted upon by diluted oil of vitriol.

Muriatic acid, in like manner, dissolves iron and zinc and also tin with effervescence, and the gas which is given off in each case exhibits the same behaviour as that obtained from iron or zinc and diluted oil of vitriol. Lead, copper, and silver are not appreciably affected.

Aquafortis is found to dissolve not only iron and zinc but also copper, lead, and silver, and to convert tin into a white substance—to attack all the metals in fact, thus justifying its name. The gas which is given off as the metal dissolves is observed to be coloured; when it is collected over water, however, it is seen to

[1] By burning carbon also in this way a most effective demonstration is given of the fact that no loss or gain of matter attends the change, and that only heat escapes; the results in the case of carbon and sulphur are particularly striking, as the products are gaseous and invisible.

be colourless, and to become coloured on coming into contact with air—oxygen and nitrogen are, therefore, added to portions of the gas over water. In this manner, not only is a new gas discovered, but also a test for oxygen; and opportunity is afforded of here calling attention to the fact that air behaves exactly as oxygen, that the oxygen in air appears to be unaffected by its association with nitrogen—that, in fact, it is uncombined. From these experiments it is obvious that metals and acids interact in a variety of ways. Finally, the dissolution of gold and platinum by aqua regia may be demonstrated.

PROBLEM VIII. *To determine what happens when oxides are treated with acids.*—In the course of the previous experiments a number of oxides have been prepared by burning various metals in air; these are found to be unchanged by water. The discovery that acids act on metals suggests a trial of the effect which acids will have on their oxides; so the oxides of zinc, iron, copper, and lead are submitted to the action of the three acids previously used. Sulphuric acid is found to dissolve zinc oxide, iron rust, and copper oxide, but no gas is evolved; excess of the oxide may be used, and the filtered liquid concentrated; the crystals which separate may be examined and compared with those obtained by dissolving the metal in sulphuric acid, &c. Litharge apparently is not changed by sulphuric acid, but red lead is, although not dissolved. Muriatic acid being used, all the oxides are found to dissolve, and in the case of red lead a greenish-yellow gas is given off possessing a most disagreeable smell: this is noted as a case for study. The product from the lead oxides is observed to crystallize out from the hot liquid on standing, so the undissolved original product is boiled up with water, and the solution is filtered, &c. Attention is thus directed to the difference in solubility of the products. Next, aquafortis is used; again all are dissolved, except the red lead, which, however, is obviously altered. In the case of the lead oxides the product is again less soluble than those afforded by the other oxides, but more soluble than the product obtained on using muriatic acid. The pupil has already been led to realize that of two substances capable of acting on a third, such as chalk gas and sulphur gas, which both combine with lime, one may be the stronger, and may turn out the other, sulphur gas turning out chalk gas from chalk. A comparison of the three acids with the object of ascertaining which is the strongest is therefore suggested: the metal or oxide is dissolved in one of the acids, and the others are then added. No positive result is obtained in case of zinc, iron, or copper, but the solution of lead in nitric acid is precipitated by muriatic and by sulphuric acid; the former precipitate is found to dissolve in boiling water and to crystallize out in exactly the same way as the substance obtained from lead oxide and muriatic acid. The sulphuric acid product is found to be almost insoluble in water, and also in muriatic and nitric acids: these observations make it possible, by examining the behaviour towards muriatic and nitric acids of the products of the action of sulphuric acid on the lead oxides, to establish the fact that the product is the same whether lead be dissolved in nitric acid and sulphuric acid be then added, or whether either of the oxides be treated with sulphuric acid. It is further evident that those acids which give difficultly soluble or insoluble products act with difficulty if at all on the metal. Other metals besides those mentioned may be now studied, and, a solvent being found, the acids which do not dissolve the metal may be added to the solution. In this way, for example, the chloride test for silver is discovered.

In experimenting with acids the pupils can hardly fail to stain their clothes and their fingers. The observation that acids alter colours serves to suggest experiments on the action of acids on colours, especially those of leaves and flowers. The use of litmus, methyl-orange, cochineal, &c., may then be explained. As various oxides have been found to "neutralize" acids, the study of their effect on the colours altered by acids is suggested. Lastly, a few experiments with vegetable and animal substances, sugar, &c., may be made, which demonstrate the corrosive action of oil of vitriol and aquafortis.

PROBLEM IX. *To determine what happens when the gas obtained by dissolving iron or zinc in sulphuric or muriatic acid is burnt.*—The gas has been observed to burn with a smokeless, odourless flame. To ascertain whether, as in all other cases of combustion previously studied, the oxygen of the air is concerned in the combustion, a burning jet of the gas is plunged into a dry cylinder full of oxygen, in which it is not only seen to continue burning, but it is also noticed that drops of liquid condense on the cylinder above the flame; this immediately suggests that the product is a liquid. The jet is found to be extinguished in nitrogen, so evidently when the gas burns it forms an oxide. The experiment is repeated, and the gas burnt in a bell jar full of oxygen over water: the water rises as the combustion proceeds, proving that the oxygen is used up. To collect a sufficient quantity of the product for examination, the dried[1] gas is burnt at a jet underneath a Florence flask through which a stream of cold water is allowed to circulate: the neck of the flask is passed through the neck of a bell jar and the flask and bell jar are clamped up in an inclined position, so that the liquid which condenses may drop into a small beaker placed below the rim of the jar. What is the liquid? It looks very like water, and is without taste or smell. Is it water? How is this to be ascertained? What are the properties of water? The knowledge previously gained here becomes of importance. It has been observed that frozen water melts at 0° C., that water boils at 100°, and that one cubic centimetre weighs one gramme at 4° C.; so the liquid is frozen by the ice-maker's mixture of ice and salt, a thermometer being plunged into it so that the solid ice forms on the bulb: the melting-point is then observed. Subsequently the boiling-point is determined, a little cotton-wool being wrapped around the bulb of the thermometer. Lastly, the density of the liquid may be determined. It is thus established that the gas yields water when burnt, and the name of the gas may now *for the first time* be mentioned and explained. The results thus obtained leave little doubt that water is an oxide of hydrogen; but in order to place this beyond doubt it is necessary to exclude nitrogen altogether. How is this to be done? Red lead is known to consist of lead and oxygen only, and readily parts with a portion at least of its oxygen; so dried oxygen is passed over red lead, which is then gently heated. Again a liquid is obtained which behaves as water, so there can be no doubt that water is an oxide of hydrogen. Water is not obtained on merely mixing oxygen and hydrogen; it is only produced when combustion takes place. To start the combustion a flame is applied to a small quantity of a mixture of the two gases: a violent explosion takes place. An opportunity is here again afforded of calling attention to the entire change in properties which takes place when the compound is formed. On heating red lead in hydrogen, lead is obtained, although on heating it alone it loses only a portion of its oxygen, and the "reduction" takes place very readily; evidently, therefore, hydrogen is a powerful agent. This observation suggests further experiments. Will it not be possible to remove oxygen by means of hydrogen from other oxides which are not altered on heating? and will not other combustible substances besides hydrogen remove oxygen from oxides?

PROBLEM X. *To determine what happens when hydrogen and other combustible substances are heated with oxides.*—Zinc oxide, iron rust, and copper oxide are now heated in a current of hydrogen: the first remains unaltered, the other two are seen to change, a liquid being formed which it cannot be doubted is water; the copper oxide evidently becomes reduced to copper. Is the iron rust similarly reduced to the metallic state? How is iron to be tested for? Iron is attracted by the magnet, and dissolves in diluted oil of vitriol with evolution of hydrogen. Applying these tests, no doubt remains that the iron rust is deprived of its oxygen.

Litharge and copper oxide may then be mixed with soot or finely powdered charcoal and heated in tubes; gas is given off which renders lime water turbid, and metallic lead or copper is obviously obtained. It is thus established that some but not all oxides may be deprived of their oxygen by means either of hydrogen or carbon. Opportunity is here afforded of explaining the manufacture of iron.

Several dried combustible organic substances, sugar, bread, and meat, may now be burnt with copper oxide in a tube the fore part of which is clean and is kept cool: liquid is seen to condense, while "chalk gas" is given off; the liquid has the appearance of water, and sufficient may easily be obtained to ascertain whether it is water. The presence of hydrogen in organic substances is thus discovered; its origin from water may now be explained, and the double function of water in the plant and animal economy may be referred to—viz. that it both enters into the composition of the animal and plant structure and also acts as a solvent. The combustion of ordinary coal gas, of alcohol, of petroleum, of oil and of candles, may then be

[1] The importance of drying the gas is realized without difficulty, as previous observations have shown that the air is moist, and as the gas is given off in presence of water, lime may be used.

studied, and the presence of hydrogen in all of these noted.

PROBLEM XI. *To determine whether oxides such as water and chalk gas may be deprived of oxygen by means of metals.*—It being found that hydrogen and carbon withdraw the oxygen from some but not from all metals, it follows that some metals have a stronger, others a weaker, hold upon or "affinity" to oxygen than has either hydrogen or carbon; the question arises whether any and which metals have so much greater an affinity to oxygen that they will withdraw it from hydrogen and carbon. Copper and iron have been found to part with oxygen, but zinc and magnesium did not, so these four metals may be studied comparatively. Steam is passed through a red-hot copper tube full of copper tacks: no change is observed. The experiment is repeated with an iron tube charged with bright iron nails: a gas is obtained which is soon recognized to be hydrogen, and on emptying out the nails they are found to be coated with black scale. Zinc and then magnesium are tried, and, like iron, are found to liberate hydrogen. Chalk gas is next passed over red-hot copper, and is found to remain unchanged, but on passing it over red-hot iron or zinc a gas is obtained which burns with a clear blue smokeless flame: this gas is not absorbed by milk of lime, but on combustion yields chalk gas, so it evidently contains carbon, and is a new combustible gas. Like hydrogen, it is found to afford an explosive mixture with oxygen. Finally, magnesium is heated in chalk gas: it is observed to burn, and the magnesium to become converted into a blackish substance unlike the white oxide formed on burning it in air. But it is to be expected that this oxide is produced, and to remove it, as it is known from previous experiments to be soluble in muriatic acid, this acid is added: a black residue is obtained. What is this? Is it not probable that it is carbon? If so, it will burn in oxygen yielding chalk gas. So the experiment is made. These experiments in which hydrogen is obtained from water and carbon from chalk gas afford the most complete "analytic" proof of the correctness of the conclusions previously arrived at regarding water and chalk gas, and which were based on "synthetic" evidence; taken together, they illustrate very clearly the two methods by which chemists determine composition.

As hydrogen and carbon form oxides from which oxygen may be removed by means of some metals but not by all, the question arises, Which has the greater hold upon or affinity to oxygen—carbon or hydrogen? As it is the easiest experiment to perform, steam is passed over red-hot charcoal: a combustible gas is obtained which yields water and chalk gas when burnt, so evidently the hydrogen is deprived of its oxygen, and this latter combines with the carbon, forming the combustible oxide of carbon. Will not carbon partly deprive chalk gas of its oxygen? The experiment is made and it is found that it will. These results afford an opportunity of calling attention to and explaining the changes which go on in ordinary fires and in a furnace.

PROBLEM XII. *To determine the composition of salt gas, and the manner in which it acts on metals and oxides.*—It has previously been demonstrated that spirits of salt or muriatic acid is prepared by acting on salt with oil of vitriol and passing the gas which is given off into water; the solution has been found capable of dissolving various metals and oxides, chalk, lime, &c., and as water alone does not dissolve these substances the effect is apparently attributable to the dissolved gas, so it becomes of interest to learn more of this gas in order that its action may be understood. It is first prepared; its extreme solubility in water is observed, and also the fact that as it dissolves much heat is given out; and it is noted that although colourless and transparent it fumes in the air. How is its composition to be determined? Is there any clue which can be followed up? Reference is made to the previous observations, and it is noted that its solution dissolves various metals with evolution of hydrogen; water alone has no such effect. Is this hydrogen derived from the water or from the dissolved gas? The gas alone is passed over heated iron turnings, and the escaping gas is collected over water: it proves to be hydrogen, so evidently salt gas is a compound of hydrogen with something else. How is this something else to be separated from the hydrogen? Do not previous experiments suggest a method? Yes, they have proved that hydrogen has a marked affinity to oxygen, and now it is recollected that on treating muriatic acid with red lead—a substance rich in oxygen—a greenish-yellow gas is obtained. The experiment is repeated on a larger scale and the gas is examined. If it is contained together with hydrogen in salt gas, perhaps salt gas will be obtained on applying a flame to a mixture of the two gases just as water is from a mixture of oxygen and hydrogen: the mixture is made and fired, and the result leaves little doubt that salt gas does consist of hydrogen in combination with the greenish-yellow gas—chlorine. Whence is this chlorine derived—from the salt or the sulphuric acid?

The notes are again consulted, and it is seen that a solution of silver in nitric acid gave a characteristic precipitate with muriatic acid but not with sulphuric, so salt solution is added to the silver solution, and a precisely similar precipitate is obtained, leaving little doubt that the chlorine is derived from the salt. It is now easily realized that the iron and zinc displace the hydrogen of the dissolved hydrogen chloride. What happens when the oxides are acted on? In addition to the metal they contain oxygen, which is known to combine readily with hydrogen, forming water; is water formed? Lime oxide is therefore heated in hydrogen chloride; a liquid is obtained which behaves exactly as a solution of hydrogen chloride in water. When the action is complete, after driving off all that is volatile, a solid remains very like fused common salt—doubtless zinc chloride, as it is to be supposed that as the hydrogen has taken the place of the zinc the chlorine has taken the place of the oxygen. What, then, is the action of hydrogen chloride on chalk? It evidently not only separates the chalk gas from the lime, but also dissolves this latter. What is formed? Dry (unslaked) lime is therefore heated in a current of hydrogen chloride. It behaves just as zinc oxide, yielding a liquid product—evidently a solution of hydrogen chloride in water, as it dissolves zinc with evolution of hydrogen, and the residue is like that of zinc chloride. The important discovery is thus made that lime also is an oxide—that chalk, in fact, is a compound of two oxides; the resemblance of lime to zinc oxide and magnesium oxide is so striking that the conclusion is almost self-evident that lime is probably a metallic oxide, and it may be here pointed out that this actually is the case. The gradual discovery of the composition of chalk in the manner indicated is an especially valuable illustration of chemical method, and serves to show how chemists are often obliged to pause in their discoveries and to await the discovery of new facts and methods of attack before they are able to completely solve many of the problems which are submitted to them. The solids obtained on dissolving zinc oxide and lime in muriatic acid and boiling down the solution, when all the water is driven off, are white solids like fused salt, but on exposure they gradually become liquid. In so doing they increase in weight, and evidently behave like sulphuric acid. Probably water is absorbed from the air: no change takes place when they are kept over sulphuric acid or dry lime. In this way two new desiccating agents are incidentally discovered.

PROBLEM XIII. *To determine the composition of washing-soda.*—The study of this substance is of importance as introducing the conception of an alkali. The preparation from salt is first described. On heating the crystals they melt and give off "steam"; the experiment is made in such a way that a quantity of the liquid is obtained sufficient to place beyond doubt that it is water. The water is found to be easily driven off on heating the crystals in the oven, and to constitute a very large proportion of the weight of the crystals. The conception of water of crystallization is thus gained. On heating the dried substance to full redness in the platinum dish, no loss occurs. The residue dissolves in water, and "soda crystals" may again be obtained from the solution, so that heat does not affect it. Perhaps acids which have been found to act so powerfully in other cases will afford some clue. On trial this is found to be the case: a colourless, odourless gas is given off, which extinguishes a burning taper. Is this perhaps nitrogen or chalk gas? The lime water test at once decides that it is the latter. So it is determined that washing-soda, like chalk, is a compound of chalk gas—but with what? With an oxide? The dried substance is heated in hydrogen chloride: chalk gas is given off as before, and a liquid which is soon recognized as water saturated with hydrogen chloride. The residue dissolves in water, and separates from the concentrated solution in crystals exactly like salt, and, in fact, is soon recognized to be salt; evidently, therefore, that which is present in salt along with chlorine is present in soda crystals along with oxygen, chalk gas, and water. The preparation of the metal sodium from soda is then explained. Acquaintance being thus made with compounds of chalk gas with two different oxides, the question arises, which oxide has the greater affinity to the chalk gas? Will lime displace sodium oxide from soda or *vice versâ?* On adding lime water to soda solution, a precipitate of chalk is formed. What does the solution contain? Lime water contains lime in combination with water; is the sodium oxide present in combination with water? Soda is boiled with milk of lime (in an iron saucepan to avoid breakage) until it no longer affects lime water; afterwards the liquid is poured off and boiled down. The product is very unlike soda: it is very caustic, and when exposed to the air becomes liquid. If it is an analogous substance to slaked lime, it should combine with chalk gas and be reconverted into soda; this is found to be the case. Caustic soda is thus discovered. Chalk and lime are known to neutralize acids; both soda and caustic soda are found to do so, and their effect on vegetable colours is found to be the reverse of that of acids. At this stage the origin of the name alkali is explained, and it is pointed out that the oxides which have been studied may be arranged in two groups of alkali-like or *alkylic* and acid-forming or *acidic* oxides, the former being derived from metals, the latter from non-metals. The production of *salts* by the union of an oxide of the one class with the oxide of the other class is then illustrated by reference to earlier experiments.

The point is now reached at which the results thus far obtained may be reconsidered. The student has been led in many cases to make discoveries precisely in the manner in which they were originally made; and it is desirable that at this stage, if not earlier, the history of the discovery of the composition of air and water, &c., should be briefly recited. It is then pointed out that a variety of substances have been analyzed and resolved into simpler substances—air into oxygen and nitrogen, water into oxygen and hydrogen, &c.; and that these simpler substances thus far have resisted all attempts to further simplify them, and are hence regarded as elements. A list of the known elements having been given, the diverse properties of the elements may be illustrated from the knowledge gained in the course of the experiments. The fact that when elements combine compounds altogether different in properties from the constituents are formed also meets with manifold illustration. Too little has been ascertained to admit of any general conclusion being arrived at with regard to the proportions in which elements combine, but it is clear that they may combine in more than one proportion since two oxides of carbon have been discovered, and in the only cases studied—viz. copper oxide and chalk—the composition has been found not to vary. The existence of various types of compounds has been recognized, and a good deal has been learnt with reference to the nature of chemical change. But, above all, the method of arriving at a knowledge of facts has been illustrated time after time in such a manner as to influence in a most important degree the habit of mind of the careful student. New facts have been discovered by the logical application of previously discovered facts: the logical use of facts, and the habit of using facts have been inculcated. This is all-important. It has become so customary to teach the facts without teaching how they have been discovered that the great majority of chemical students never truly learn the use of facts; they consequently pursue their daily avocations in a perfunctory manner, and only in exceptional cases manifest those qualities which are required of the investigator; their enthusiasm is not awakened, and they have little desire or inclination to add to the stock of facts. It must not for one moment be supposed that the object of teaching chemistry in schools is to make all chemists. Habits of regulated inquisitiveness, such as must gradually be acquired by all who intelligently follow a course such as has been sketched out, are, however, of value in every walk of life; and certainly the desire to understand all that comes under observation should as far as possible be implanted in everyone.

STAGE V.—*The quantitative stage.*

The *quantitative* composition of many of the substances which have previously been studied qualitatively should now be determined—in some cases by the teacher in face of the pupils, so that every detail may be observed and all the results recorded; in other cases by the pupils.

The composition of water is first determined by Dumas' method; this may easily be done, and fairly accurate results may be obtained in the course of a couple of hours. The results obtained by Dumas and subsequent workers should then all be cited, and, attention having been drawn to the extent to which such experiments are necessarily subject to error, the evidence which the results afford that hydrogen and oxygen combine in certain *fixed and invariable proportions* to form water is especially insisted upon.

The composition of chalk gas is next determined; this also is easily done, as impure carbon (lampblack) may be burnt and the hydrogen allowed for. Again, attention is directed to the results obtained by skilled workers, and the evidence which they afford that chalk gas never varies in composition.

The composition of copper oxide has already been ascertained; it may be re-determined by reducing the oxide in hydrogen: in fact, in determining the composition of water.

The lead oxides may be reduced in a similar manner, the oxide obtained by igniting white lead as well as red lead and the brown oxide obtained by treating red lead with nitric acid being used. In this way it is ascertained that the brown oxide is the highest oxide; the loss in weight which this oxide suffers when ignited may then be determined.

Tabulating the results thus obtained, after calculating with what amount of the particular element that quantity of oxygen is associated which in water is combined with one part by weight (*unit weight*) of hydrogen, numbers such as the following are obtained:—

1 part of hydrogen is combined with 8 parts of oxygen in water.

3 parts of carbon are combined with 8 parts of oxygen in chalk gas.

31·5 parts of copper are combined with 8 parts of oxygen in copper oxide.

103·5 parts of lead is combined with 8 parts of oxygen in lead oxide (litharge).

51·8 parts of lead are combined with 8 parts of oxygen in lead oxide (brown).

These clearly illustrate the fact that elements combine in very different proportions, and the results obtained with the lead oxides afford also an illustration of combination in multiple proportion.

The amounts of silver and lead nitrates formed on dissolving silver and lead in nitric acid are next determined by evaporating the solutions of known weights of the metals in porcelain crucibles on the water-bath, and then drying until the weight is constant; accurate results may be easily obtained, and these two exercises afford most valuable training. The nitrates are subsequently evaporated with muriatic acid and the weights of the products determined. What are these products? Does the metal simply take the place of the hydrogen in hydrogen chloride as zinc does when it dissolves in muriatic acid? If so, the products are silver and lead chlorides, and it may be expected that the same substances will be obtained—that the same increase in weight will be observed, when, say, silver is combined directly with chlorine as when it is dissolved in nitric acid and the solution is precipitated with muriatic acid or salt. Silver is, therefore, heated in chlorine, and is found to increase in weight to the same extent as when it is dissolved in nitric acid, &c.; a given weight of silver precipitated by salt is also found to increase to the same extent as when it is directly combined with chlorine. The composition of silver chloride having thus been ascertained, the amount of chlorine in salt is determined. The composition of salt being ascertained, purified dried washing-soda is converted into salt, and also the amount of chalk gas which it contains is determined: from the data, the composition of sodium oxide may be calculated. In like manner the composition of lime may be ascertained by converting chalk into chloride by igniting it in hydrogen chloride, and then determining the chlorine in the chloride; the same method may be applied to the determination of the composition of the oxides and chlorides of zinc, magnesium, and copper.

Discussing these various results, and comparing the quantities of oxygen and of chlorine which combine with any one of the metals examined, it is seen that in every case about 35·4 parts of chlorine take the place of 8 parts of oxygen. Combination in *reciprocal proportions* is thus illustrated, and by considering the composition of chalk and washing-soda it may be shown that this applies equally to compounds of two and to compounds of three elements. As 35·4 parts of chlorine are found in every case to correspond to 8 parts of oxygen, it is to be expected that hydrogen chloride contains one part of hydrogen in combination with 35·4 parts of chlorine; a solution containing a known weight of hydrogen chloride is, therefore, prepared by passing the gas into a tared flask containing water and the chlorine is then determined.

It being thus clearly established what are *equivalent* weights of elements, the conception of equivalents may be further developed by exercises in acidimetry carried out by the pupils themselves. The proportions in which washing-soda and hydrogen chloride interact may be determined by mixing solutions of known strength until neutralization is effected; if the solution be evaporated and the chloride weighed, the results may be used in calculating the composition of hydrogen chloride; they serve, in fact, as a check on the conclusions previously arrived at as to the composition of washing-soda and hydrogen chloride. Solutions of sulphuric and nitric acid may be similarly neutralized, and, the amounts of sulphate and nitrate formed having been ascertained, the equivalents of the acids may be calculated on the assumption that the action is of the same kind as takes place in the case of hydrogen chloride. Determinations of the strengths of acids, &c., may then be made. In a similar manner the volumetric estimation of silver may be taught, and the percentage of silver in coinage and other alloys determined.

Such a series of quantitative exercises as the foregoing, when carried out *before* and to a considerable extent *by* the pupils, undoubtedly affords mental discipline of the very highest order, and is effective of good in so many ways that the value of such teaching cannot be over-estimated. The failure to grasp quantitative relationships which examiners have so frequently to deplore is without question largely, if not alone, due to students' entire ignorance of the manner in which such relationships have been determined. Moreover, the appreciation by the general public of the principles on which quantitative analysis is founded would undoubtedly be directly productive of good in a multiplicity of cases.

STAGE VI.—*Studies of the physical properties of gases in comparison with those of liquids and solids. The molecular and atomic theories and their application.*

A series of quantitative experiments on the effect of heat on solids, liquids, and gases should now be made, and these should be followed by similar experiments on the effect of pressure; the similar behaviour of gases, and the dissimilar behaviour of liquids and solids, is thus made clear. The condensation of gases is then demonstrated and explained, and also the conversion of solids and liquids into gases, and the dependence of boiling-point on pressure and temperature. Regnault's method of determining gaseous densities is studied, and the method of determining vapour densities is illustrated. The molecular constitution of a gas is now discussed; the phenomena of gaseous and liquid diffusion are studied, and a brief reference is made to the kinetic theory of gases; then Avogadro's theorem is expounded and applied to the determination of molecular weights; and eventually the atomic theory is explained, and the manner in which atomic weights are ascertained is brought home to the pupils. The use of symbols must then be taught. Finally, the classification of the elements in accordance with the periodic law should be explained.

It is all-important that at least a large proportion of the experiments in each of the stages should be made by the pupils; but even if this were not done, and the lessons took the form of demonstrations, much valuable instruction might still be given.

The majority of pupils probably would not proceed to the fifth and sixth stages; but those who perforce must terminate their studies without gaining any knowledge of chemical philosophy should unfailingly be led to make a few simple quantitative experiments: for example, to determine silver volumetrically, and the method of determining the composition of water and chalk gas should be demonstrated in their presence: and it may be added that, if only the examples in Stages I. and II. and Problems I. to V. of Stage III. were thoroughly worked out, most important educational training would be given, and much valuable information as to the nature of common phenomena would be gained.

The complete course would undoubtedly take up considerable time, but so does a satisfactory mathematical or classical course of study, and it is absurd to suppose that useful training in science is to be imparted in a few months. If instruction be given in the manner suggested at all generally, it will be necessary, however, to modify the present system of testing results. Pupils could not be expected to pass at an early age examinations such as are at present held, and awards would have to be based chiefly on an inspection of the classes at work and of note-books and on *vivâ voce* questioning. But all are agreed that the present system of payment on results tested by a terminal examination is a most unhealthy one, and that a more rational system *must* be substituted for it. I may suggest that if members of the staff of science colleges, such as are now established in so many towns, could be appointed *supervising inspectors*, whose duty it would be to advise teachers in schools and *occasionally* to inspect the teaching in company with the permanent inspector, it would be possible to secure the assistance of a body of men who are in touch with scientific progress and conversant with the improvements which are being effected. A man who "once an inspector is always an inspector" of necessity must get into a rut, and will escape from the wholesome leavening and rousing influence which is always more or less felt by those whose office it is to follow the march of scientific progress.

It should also here be pointed out that the great majority of the experiments and exercises described may be carried out with very simple apparatus, and with slight provision in the way of special laboratory accommodation. In but very few cases is there any production of unpleasant smells or noxious fumes. It is, in fact, a mistake to suppose that an elaborately fitted laboratory is in every case essential for successful teaching: much might be done in an ordinary schoolroom provided with a demonstration bench for the use of the teacher, a draught closet over the fire-place, a sink, a raised table for balances (raised so that the teacher might see what was going on), a cupboard for apparatus, and a long narrow bench provided with gas-burners at which, say, twenty pupils might stand, ten a-side. At present the Science and Art Department will not recognize "practical chemistry" unless it be taught in a laboratory fitted up in a certain specified manner, and their regulations are such as to enforce the provision of expensive laboratories in all cases where it is desired to obtain the grant. If greater latitude in fittings were allowed, more attention being paid to the character of the work done and less to the tools with which it is accomplished, probably much less money would be wasted by inexperienced school authorities in providing special laboratories, and there would be much greater readiness displayed to enter on the teaching of experimental science. The course which has been sketched out is one which doubtless might well be modified in a variety of ways according to circumstances. Thus many simple exercises in mechanics, in addition to those directly mentioned, might be introduced into Stage II., and the mechanical properties of common materials might be somewhat fully studied at this stage in districts where engineering trades are largely established, and where such knowledge would be specially valuable. In like manner the physical effects of heat on substsnces might be studied in Stage III. instead of Stage VI. And there are other chemical problems and simple exercises besides those described which might be substituted for some of them, or included in the course.

Probably, however, it would be found undesirable, if not impossible, as a rule, to continue the teaching of chemistry proper much, if at all, beyond the stage indicated in this scheme. Other subjects will have a prior claim should it ever be deemed essential to include in a comprehensive scheme of school education the elements of the chief physical and physiological sciences; it certainly is of primary importance to introduce at as early a period as possible the conception of energy, and to explain the mechanical theory of heat, so that later on it may be possible to discuss the efficiency of heat and other engines; and, until the laws of the electric current are understood, the subject of chemical change can never be properly considered.

In many cases, where it is convenient or desirable to continue the chemical studies, it probably will be advantageous as a rule that they have reference to specific (local) requirements—*e.g.* to agriculture in schools in agricultural districts; to food materials and physiology in the case of girls especially, &c. But in any case more consideration must be paid in the future in schools where chemistry is taught to educational requirements—the teaching must have reference to the requirements of the general public; and it must be remembered that the college, not the school, is the place for the complete study of a subject.

With the object of presenting in an available form information as to the position occupied by chemistry in Board and other public elementary schools, which are controlled either by the Education Department, Whitehall, or the Science and Art Department, South Kensington, the Committee now present a report on the subject which has been prepared by Prof. Smithells. A consideration of this statement will show that, as in the higher grade public schools, with which the Report of the Committee last year was chiefly concerned, the condition of the teaching in public elementary schools is far from satisfactory. As a rule chemistry is not taught on the proper lines. The pupils frequently receive the same kind of instruction in chemistry as they would at a later stage if they were preparing for a professional or technical career; consequently the subject has failed to provide that mental education which it should be the main object of elementary teaching to develop. It appears, too, that in many of these schools physical science has not hitherto been regarded as a necessary part of the educational scheme. It is essential that this state of affairs should be altered, and that physical science should occupy a more favourable position in the Education Code, and that its teaching should be more thoroughly controlled.

It is to be hoped also that the Education Department, as well at the Science and Art Department, South Kensington, will take steps to arrange a more efficient mode of inspecting science teaching than that at present in vogue, which can only be regarded as satisfactory from a purely statistical standpoint. Under the present system little or no control can be exercised over the science teaching, since the Whitehall inspectors are, as a rule, not qualified to form an opinion as to its value. There would seem to be no difficulty in obtaining the services of properly qualified persons to act as additional inspectors for the purpose of reporting on the character of the science teaching. It is probable that many of the professors and lecturers in University Colleges, and other educational institutions, might be willing to take part in such inspection, and it would thus become possible to maintain a high standard of excellence in the teaching.

THE GEOLOGICAL PAPERS AT THE BRITISH ASSOCIATION.

ON Thursday morning the first business of Section C was to hear Prof. Milne's ninth Report on the earthquake and volcanic phenomena of Japan, in which a list of seventy-nine earthquakes occurring between June 1888 and March 1889 is given. After a paper by Dr. Naumann, which will be referred to later on, Mr. T. P. Barkas read a paper on footprints of four-, three-, and two-toed animals, discovered in Lower Carboniferous sandstones near Otterburn, of which he exhibited specimens. A paper by Mr. Mellard Reade reviewed the chief theories advanced to account for the Lower Triassic rocks, and advocates their formation by tidal action in straits, seas, and bays from the denudation of the rocks of the Channel, Mendips, Belgian coal-field, Pennine, and the Old Red of Herefordshire.

Friday's sitting opened with Dr. A. Geikie's paper on the age and origin of the crystalline schists of Norway. In the Trondhjem region ordinary sedimentary rocks, much disturbed, contain Lower and Upper Silurian fossils, and are underlain by basic lavas and tuffs, succeeded by grits, slates, and schists with black pyritous and carbonaceous beds. Traced southwards, the whole series becomes progressively more crumpled and crystalline until it passes into a group of twisted mica schists, in which, however, the pyritous shales, although converted into mica schists, are still recognizable. Specimens were exhibited to show every step of metamorphism from an amorphous igneous rock to a perfect schist, the change being sometimes visible in a hand specimen In Bergen the author confirmed the discovery of fossils by Dr. Reusch in a frilled mica schist or phyllite, proving that the regonial metamorphism in this area was of post-Silurian date. Mr. Marr followed with a description of the Skiddaw slates on the east side of Brownber, where quartz veins have been intruded between the bedding planes, the rock has been contorted, and converted into a rock composed largely of mica and secondary quartz, and exhibiting *ausweichungsclivage*, in fact a mica schist. Prof. Bonney contributed a paper showing that the limestones associated with crystalline rocks were coarsely crystalline as a rule, but that pressure often obliterated this coarse texture by crushing, and thus could only be appealed to as a minor agent in producing crystallization; a further paper by the same author dealt with the fossils obtained amongst the crystalline schists in the Val Canaria, Val Piora, Nufenen Pass, and Lukmanier Pass; he concluded that in the first two localities the relations of the rocks had been misunderstood, while in the last two the fossils were in a rock whose minerals were in a very different state from those in the older crystalline schists. Mr. Watts exhibited a collection of Belemnites from the rocks of the Lukmanier Pass. Dr. Hatch described potash and soda felsites from the Lower Silurian of Ireland, which were ancient equivalents of the rhyolites and pantellerites of to-day; and Mr. A. R. Hunt brought forward a view that the granites of Dartmoor and of the Channel were of pre-Devonian and probably Archæan age. Mr. Teall sent an interesting communication on the amygdaloids of the Tynemouth dyke, in which he summarized the history of the rock as follows: (1) development of granular aggregates of felspar allied to anorthite under plutonic conditions; (2) addition of new felspar substance to these, giving them outward crystalline form; (3) formation of lath-shaped felspars; (4) separation of augite; (5) formation of vesicles probably due to relief of pressure when the magma rose into a fissure; (6) filling of some of these vesicles with interstitial matter which probably oozed into them from the surrounding liquid magma, as they are seen in all stages of filling; (7) consolidation of interstitial matter; (8) filling up of the rest of the vesicles with carbonates. Mr. Swan exhibited specimens of marble from Paros, and described the new and old quarries; and then the Section listened to an account from Dr. Fridtjof Nansen of the geological bearings of his journey across Greenland.

Greenland is covered by a shield of ice rising to a height of 9000 or 10,000 feet in the centre, where it probably covers an area of mountains and valleys, and not a table-land, reduced to a gently sloping surface, and even polished, by the wind. The only evidence of ice melting on the surface in the interior consists of thin ice crusts at varying depths. The enormous pressure of the ice mass forces it out partly as ice and partly as water melted by friction, thus giving rise to the rivers, which flow even in winter. The great rate at which the ice flows out into the fjords makes the author an advocate for the agency of ice in forming these features.

On Saturday, Prof. W. C. Williamson read a paper in which he acknowledged the help he had received from all parts of the world in acquiring specimens and slides of coal and mineral charcoal from many English, Welsh, and Scotch localities, as well as from Japan, New Zealand, America, Europe, Asia, and Australia. The inquiry was still proceeding, with a view to ascertain the nature and origin of this mineral charcoal, and to estimate the extent to which cryptogamic spores contributed to coal formation. Prof. Williamson further stated that in *Lyginodendron Oldhamium*, he added a fern to the other cryptogams in which exogenous growth took place, and announced what he termed another botanical heresy, that in the Carboniferous Lycopods the vascular bundle enlarged into a ring inclosing a medulla which enlarged *pari passu* with the ring. Prof. T. R. Jones reviewed the advancement made by himself and others to our knowledge of the Palæozoic Phyllopoda; and Dr. Johnston-Lavis's Report on Vesuvius was presented. This Report announces that Messrs. Philip and Son will shortly publish the map of Vesuvius; it further gives a diagram of the cone in 1887 and 1886 (? 1888), and three taken in January, May, and August, 1889, so as to show the changes resultant on overflows of lava, formation of fissures, and building of new cones. The Report concludes with a further account of the new railway tunnels in the Phlegræan Fields.

Further specimens of the peculiar coral-like structures from the limestone of Culdaff have been obtained by the Geological Survey, and some of these, with photographs, were exhibited to the Section by Prof. Hull. Some foreign palæontologists, judging from the photographs, regarded them as organic, and referred them to Favistella, but English palæontologists give only a hesitating assent to this view. Mr. Cameron described Kellaway's sand and doggers from exposures near Bedford, and Mr. Vine described sixteen species of Stomatopora and Proboscina from the Hunstanton Red Chalk.

On Monday, Mr. Ussher's paper on the Devonian rocks of Britain was presented. He divided the rocks into three typical areas, in each of which they presented peculiar characters. In North Devon there are arenaceous deposits indicating shoal water; in South Devon the rocks are variable, with sporadic volcanic and coral deposits; while in Cornwall and Devon, west of Dartmoor, the succession, though much disturbed and faulted, consists chiefly of mud and slates. A table is given, correlating the principal divisions in these three areas with their Franco-Belgian and German equivalents. An important paper by Prof. Lebour and Mr. Marley, on the South Durham salt industry and the extension of the Durham coal-field, followed. The area of proved salt amounted to at least twenty square miles, and although it had been found not to extend to Seaton Carew, there was no doubt that the eastern and northern borings at South Bank and North Ormesby did not mark the limits of the salt in those directions. The thin coals found in the Seaton boring were regarded by Prof. Lebour as being of gannister or millstone-grit age, and hence of little value except in giving an idea of the structure of the Carboniferous rocks below their red-rock covering. Mr. De Rance's Underground-water Report gave the details of some of these borings, as well as others from Devon, Worcester, Leicester, Lincoln, Lancashire, Hertfordshire, and the south of England. Dr. Embleton contributed a description of *Loxomma Allmanii* from the Northumberland coal-field; Dr. Traquair, of Devonian fishes from Scannenae Bay and Campbellton, in Canada; and Mr. Smith Woodward, of *Onychodus* from Spitzbergen, and of six new species and two new genera of Liassic fishes. Dr. R. Laing read a paper on a Neolithic interment in Robin Hood Cave, and on the discovery of *Felis brevirostris* in a Pleistocene deposit in the same cavern.

The Section then joined with Section A to hear a joint paper by Profs. Thorpe and Rücker, on the relation between the geological constitution and magnetic state of the British Isles. In this the authors recorded that the magnetic elements had been determined at 200 stations in the United Kingdom, with the result that the declination was found to be subject to local or regional disturbing causes centred in a comparatively small number of spots or lines distributed in various parts of England. The regions mentioned are: (1) the fault-line of the Caledonian Canal; (2) the basalt of the Inner Hebrides; (3) the coal-field of South Scotland; (4) the region of South-East Yorkshire, where the Jurassic rocks are thin; (5) the basalt of Mid-Wales and Shropshire; (6) the line of the "London Palæozoic Ridge"; (7) the basalt of Antrim; (8) the igneous rocks of Connemara. All the principal masses of basalt, and those spots where geologists know or suspect the older rocks to be near the surface, form centres or lines of attraction. As the result of this and of the following reasons, the authors are strongly of opinion that the disturbance is due, not to earth-currents, but to local magnetic rocks, such as basalt, or others like the Malvern diorite, which, though not strongly magnetic in the laboratory, produces a deviation of 20′ of arc even at a distance of a mile from the axis. Only small earth-currents, or none, were detected at such places as Melton Mowbray; and near Reading and Windsor, where the disturbance was great, the earth-currents must circulate *round* the disturbed districts in a manner for which it would be difficult to find an adequate physical cause, while, if the currents are deep-seated, it is not easy to understand the extreme localization of their action. In connection with this paper we may note the exhibition, by Prof. Hull, of a piece of magnetically polar diorite, and a paper by Dr. Edward Naumann, in which he advocated a magnetic survey of the globe, and brought forward a set of results from Japan and elsewhere to show the dependence of magnetic lines on lines of fault, fissure, and elevation. He, however, attributed the magnetic disturbance to the deflection of earth-currents by the great lines of fissure and tectonic disturbance.

Tuesday was chiefly devoted to Pleistocene papers, opened by Dr. Crosskey, who exhibited a large map showing the distribution of Welsh, Lake Country, Scotch, and local erratics. His report described erratics reported by the Yorkshire Boulder Committee and by Mr. Bucknill in Lancashire, and drew attention to (1) the grouping of erratics from special localities; (2) the occasional mingling of groups; (3) the occurrence of high and low level erratics; and (4) the distribution of trails of the latter in accordance with existing physical features. Mr. Whitaker described a deep and steep-sided channel filled with drift in the Cam Valley; Mr. Lamplugh, a new locality for the Arctic shell bed in the boulder clay on Flamborough Head; and Mr. Howorth contributed two papers on which there was considerable discussion. In the first he combated the theory of an ice-cap, on the grounds that many northern lands had no drift, that the southern glaciation was contemporaneous and not alternate with the northern and that in New Zealand and Australia there is nothing corresponding to the drift phenomena of the northern hemisphere, that there is little or no evidence of other earlier glacial periods, that palæontological evidence is against such a theory, and that the advance of ice-sheets over hundreds of miles of plain without any *vis a tergo* is a physical impossibility; in the second, after showing that there is evidence of a connection in Pleistocene times between Siberia and America, not by way of Japan, but probably through the shallow Arctic seas to the north, he considers that the necessary elevation of 25 or 30 fathoms would make the great Siberian rivers flow southward, and terminate in an inland sea stretching east from the Caspian, just as the principal rivers of Russia (Siberia in Europe) now flow into the Black Sea and Caspian. In the discussion it was, however, pointed out that many of the rivers flowed far too rapidly to have their directions thus reversed.

Among the other papers were: one by Prof. Haddon, describing the volcanic and coral deposits of the islands in Torres Straits, where no proof of elevation or of subsidence was to be obtained; one by Mr. Dorsey, on the Witwatersrande Gold-fields; a Report by Mr. Bell, on the manure gravels of Wexford; and one by Dr. F. Clowes, describing rocks at Bramcote and Stapleford cemented by barium sulphate, and the occurrence of the same substance deposited in pipes and water-boxes connected with the pumps of Durham collieries.

On Saturday Mr. Starkie Gardner's report on the Osborne and Bembridge floras of the Isle of Wight and the correlation of the Bovey beds with beds of about Bracklesham age was read, followed by a short paper of Prof. Green's on the concretionary nodules formed by molecular rearrangement into radial crystalline groups of the tufaceous deposits of the magnesian limestone. Mr. Topley next gave an admirable *résumé* of the work of the Geological Survey in Northumberland and Durham, which have been mapped on the 6-inch scale, and published in two sets of "drift maps" and "solid maps" on the 1-inch. He noted the whole sedimentary series from the Silurian to the Trias, the glacial beds, and the numerous intrusive and interbedded igneous rocks. The last paper was an extremely interesting one by Mr. R. H. Tiddeman on concurrent faulting and deposit in Carboniferous times. The author describes three branches of the Craven group of faults, and then shows that there are vast differences between the quality of the Pendleside grits and Bowland shales on one side of the fault and the corresponding Yoredale series on the other, while the 5500 feet of Carboniferous limestone on the north side of the faults is in strong contrast to the 800 feet on the other side, suggesting great differences in the conditions of deposit. As the faults form the boundary between the two types of rocks, as there is no trace of transition there, and as the thickest beds are on the down-throw side, the author suggests that faulting must have gone on contemporaneously with the deposit. A note was appended describing knolls of crystalline limestone full of fossils and bordered by limestone breccias, which were regarded as reefs growing in the Carboniferous ocean.

Reviewing this list of papers, it is obvious that, though many of them were not of a class to interest the somewhat popular audience which listened to them, there are a large number of great scientific interest which mark a very considerable advance made in our knowledge during the past year.

THE BIOLOGICAL PAPERS AT THE BRITISH ASSOCIATION.

As has been the custom for the last few years, a good deal of time was devoted to the discussion of topics of general biological interest. The subjects selected for these discussions were, "The Transmission of Acquired Characters" and "The Utility of Specific Characters," which were respectively opened by Mr. E. B. Poulton, F.R.S., and Prof. Romanes, F.R.S. There were also an extremely large number of botanical and zoological papers, but no physiological papers, owing to the absence of most of the physiologists, who were attending the Physiological Congress at Basle. In the following account only a few of these papers are abstracted, as it would be impossible to do justice to all in a limited space.

Mr. Romanes opened a discussion on specific characters as useful and indifferent. The question to be debated was, whether *all* characters were adaptive, and had been brought about by natural selection, or whether there were not specific characters which had no utilitarian significance? The naturalists who hold the former view were apt to beg the question by assuming that, if a given character could not be explained as due to utilitarian principles, it was simply due to a failure to see the need for it; this way of dealing with the question is really unscientific dogmatism. The author had selected certain groups, and tabulated the various specific characters, placing on one side those which were conceivably of advantage, and on the other side those which were apparently useless; the latter were found to preponderate. This was especially clear in the coloration of birds: to take one-instance, the breast and abdomen of woodpeckers are variously coloured, and yet these parts of the body are habitually concealed; here it is most difficult to conceive how natural selection can have been the cause of the various modifications. It must, in fact, be admitted that other influences besides natural selection have led to the production of specific characters which are not in any way useful as such. Sexual selection, in the first place, although Mr. Wallace rejects it, must be considered as important. There is an enormous amount of evidence that climate—as we summarize a vast number of external conditions of life—has a uniform and permament influence upon specific characters. A striking evidence of this influence is seen in the faunas of caves; here we see a loss of coloration and other peculiarities in the most different groups of animals. It has been attempted to explain this change as due to natural selection acting directly upon their physiological constitutions, and so indirectly upon their colours. This explanation would be reasonable if only one class of animals were concerned; but to assume that representatives of the most diverse classes of animals are acted upon in an identical fashion by natural selection is to assume too much; the changes must be due to the direct influence of the environment. Weismann's use of "panmixia," or negative natural selection, to account for such changes, fails, inasmuch as it should also follow that the fauna of the deep sea, which is exposed to identical conditions as regards darkness, and even temperature, should show an absence of coloration; but it is notorious that the reverse is the case. Again, the rabbits of the island of Porto Santo, near Madeira, which are the progeny of a few pairs introduced in the fifteenth century, differ in certain peculiarities of coloration which cannot be regarded as adaptive: in so short a time as four years some of these rabbits, when brought to England, reverted to the original type; this seems to be the clearest case of the direct influence of climate. Food is known to have a direct influence on coloration, but as yet there is not very much definitely known about these influences; for instance, the bullfinch turns black when fed upon hempseed, and other birds change their colour when fed with cayenne pepper; there can be no doubt that various substances exist in nature which have a similar direct effect upon the plumage of birds which feed upon them. Isolation is another cause of non-beneficial change. So much, then, for specific characters. If the theory of natural selection is good as a theory of the origin of species, it must likewise be good as a theory of the origin of genera; and if specific characters must necessarily all be "useful," so must generic characters. If the doctrine of utility as universal be conceded to fail as regards genera and all the higher taxonomic divisions, it appears inconsistent to maintain that it must necessarily hold as regards species: it is not supposed to hold as regards varieties. This seems to be a most illogical position.

In a paper on the antherozoids of Cryptogams, by Mr. Alfred W. Bennett, the object of the author was to bring out the difference between the two modes in which the ciliated fertilizing organs of Cryptogams are formed, the first type being that which occurs in Vascular Cryptogams, Muscineæ, and Characeæ, the second in Algæ (excluding Characeæ). The essential character of the first type is that the antherozoid is formed from the nucleus only of its mother-cell, the whole of the rest of its protoplasm being consumed in the development of the antherozoid. The vibratile cilia which give to the mature antherozoid its power of rapid movement proceed from a peripheral layer of hyaline protoplasm belonging to the nucleus. In ferns and other vascular cryptogams these cilia are very numerous, forming a tuft attached to the anterior end of the antherozoid. The antherozoids of Muscineæ (Musci and Hepaticæ) and those of Characeæ have only two very long and slender cilia attached in the same position. The structure and mode of development of these organs is almost identical in these two classes. In the Fucaceæ, on the other hand, which may be taken as the highest type of Algæ with ciliated antherozoids, the structure of the antherozoid is altogether different. It is a naked cell, not inclosed in a cellulose-wall, with cytoplasm, nucleus, and pigment-spot; the two cilia both spring from a spot in close proximity to the eye-spot, although one of them is attached to the body of the antherozoid for a portion of its length. The importance of the above facts was pointed out in support of the view that the Characeæ are more nearly related to the Muscineæ than to the true Algæ.

Mr. Poulton read a paper "On the Supposed Transmission of Acquired Characters." The position taken up by Weismann is that acquired characters, *i.e.* characters produced by the incidence of external forces upon the individual body are not in any case inherited. The evidence for such transmission might be direct or indirect; to the former category would belong transmission of mutilations which would be undoubtedly impressed upon the individual body by external influences; the evidence might also be indirect; if it could be shown that evolution was impossible without accepting this principle we should have to accept it. The evidence of transmission of mutilations is not strong, and Prof. Windle has argued very forcibly that monstrosities were due to peculiarities of the ovum and not to external forces. The supposed hereditary effects of use and disuse were unsupported by any proof that the modifications of organs affected by use or disuse had been more complete or more rapid than that of organs not so affected. With regard to instinct, Dr. Romanes had suggested a difficulty—that was, the instinct of certain wasps to sting and paralyze the nerve centres of their prey. But it must be remembered that the benefits arising from this instinct were felt not by the wasps themselves, but by their progeny.

The subject was continued by Mr. Francis Galton, who read a paper entitled, "Feasible Experiments on the Possibility of transmitting Acquired Habits by means of Inheritance," in the course of which he said that feasible experiments have yet to be designed that shall be accepted as crucial tests of the possibility of a parent transmitting a *congenital* aptitude to his children, which he himself possessed, *not congenitally*, but merely through long and distasteful practice under some sort of compulsion. The requirements are to eliminate all possibility of parental or social teaching, to bring up all the descendants in the same way, to make simultaneous experiments on many broods during many generations, and, lastly, to economize time, money, and labour. This list of requirements points with emphasis to experimenting on creatures that are reared from eggs, as fowls, fishes, and moths. *Fowls.*—The largely extending practice of hatching eggs in incubators for commercial purposes, and the varied aptitudes of poultry, make them very suitable subjects. Birds are said to have an instinctive dread of various insects; hence mimetic insects, that are really good for food, are avoided by them. Do such insects exist, and could they be easily reared, which poultry would avoid at first, though experience would soon teach them to like and to eat greedily? Similarly as regards sounds and cries, which would frighten at first, but afterwards be welcomed as signals for food, &c. Would the stocks of two breeders, one of whom adopted such experiments as these and the other did not, differ in instinct after many generations? *Fish.*—The experiment (quoted by Darwin) of Möbius with the pike, using a trough of water divided by a glass plate into two compartments, in one of which was the pike and in the other were minnows, was mentioned as an example. The pike, after dashing at the minnows many times, and each time being checked and hurt by the glass plate, during some weeks, finally abandoned all attempts to seize them, so that when the plate was removed the pike never afterwards ventured to attack the minnows. The question, then, is, whether fish reared for some generations under conditions which compelled them to adopt habits not conformable to their natures would show any corresponding change of instinct. Of course each generation would be reared in a separate tank from its parents. *Moths.*—Experiments have been made for the author by Mr. Frederic Merrifield with *Selenia illustraria*, which has two broods yearly. They are being made for quite another purpose, but have already shown the ease of breeding hardy moths on a large scale when the art of doing so is well understood. All larvæ are fastidious in their diet, but it may well be that certain food which they would not touch at first would after a while be greedily eaten, and be found perfectly wholesome. Ezperiments on the lines here suggested ought to show the proportion of cases in which acquired aptitudes of several kinds are *certainty not* inherited. They might also, perhaps, show that in a small proportion of cases they *certainly are.* Thus limits would be fixed within which doubt remained permissible. The object of this paper is to invite experts to discuss the details of the most appropriate experiments.

Prof. F. O. Bower read a paper on the meristems of ferns as a study in phylogeny. The author has found as the result of examination of the growing points of root, stem, leaf, and of the sporangium in a considerable number of ferns, that as regards their complexity of structure these plants form a natural series, starting from the filmy ferns, which are the simplest, and proceeding through the Polypodiaceæ and Osmundaceæ to the Marattias: in the latter the whole structure of the meristems, as well as of the mature organs of the sporophyte, is bulky and massive, a character which is well suited to growth in subaërial and dry situations; while in the former the whole structure is relatively delicate, and less complex, and suited rather to a subaquatic habitat. A parallel progression from the simpler to the more complex is to be traced also in the prothallus or oophyte of these plants, and the general conclusion is drawn from these observations that the series of the Filicineæ illustrates—perhaps more clearly than any other phylum—the rise of a race of plants from the aquatic to the subaërial habit. Nevertheless they still retain in the mode of fertilization the trace of the aquatic habit, which is only lost in the higher Phanerogamic plants, where the pollen-tube renders unnecessary the presence of fluid water at the moment of fertilization.

The paper by Prof. Hartog, on the structure of *Saprolegnia*, contained an account of the structure of the nucleus and of its division, and also of some remarkable facts concerning fertilization; careful observation showed that nothing whatever passed from the antheridium into the oosphere or the oosporangium during fertilization.

In the paper entitled "Contributions to our Knowledge of the Fresh-water Oligochæta," by Mr. F. E. Beddard, the most important new point was the description of the sexual organs of *Dero*, which have not yet been described; they were stated to agree entirely with those of *Nais*, except that there were no genital setæ.

Mr. Robert Irvine and Dr. G. Sims Woodhead, in their paper on the secretion of carbonate of lime by animals, stated that hens supplied with any salt of lime produce normal egg-shells composed of carbonate of lime. They cannot make shells from magnesium or strontium carbonate. Crustacea, such as crabs, cannot assimilate sulphate of lime from the sea-water to form their exo-skeleton. They can form their shells from calcium chloride. In the egg-shell, the organic and inorganic material are both secreted by cells separated from the epithelial cells. In the crab-shell, the organic material (chitin) remains attached to the epithelial cells, and in this the lime salts are deposited, probably by a process of dialysis, while in the case of bone, the cells are not epithelial in character, the matrix, though separate, is closely associated with the cells, especially during its formation, and the lime is deposited in the matrix, apparently by a process of dialysis. Phosphoric acid, combined with alkalies and alkaline earths, acts as the carrier of the lime salt to the secreting cells. While in the blood, the lime salt is as a phosphate, it may be thrown out mostly as carbonate on meeting nascent carbonic acid at the secreting cells. Lime salts, of whatever form, are deposited only in vitally inactive tissue, such as bone matrix, chitin, or tissues that have undergone degeneration. Although the tissue be dead, deposition may go on. Carbonate of lime may be formed in sea-water as follows: the carbonate of ammonia produced by the decomposition of the effete products of animals, urea, &c., decomposes a portion of the sulphate of lime in the sea-water with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed.

Sir John Lubbock read a paper on the shape of the oak-leaf and the leaves of the Guelder roses. The leaf of the evergreen oak is small in comparison with that of the English oak, and its margin is entire. During winter the leaf is protected by scales, which are not proportionately larger in the English oak; hence the leaf must be more folded in the bud, and the peculiar shape of the leaf may be shown by models to be due to the shortness of the bud in comparison with the length of the leaf; moreover, the two sides of the leaf are differently curved, hence the asymmetry. With regard to the Guelder roses, there are two species in this country which have very dissimilar leaves: in one form they are oval and very hairy when young; in the other they are trilobate, smooth, and furnished with stipules. In the former species the hairy covering protects the young leaves, but in the latter the outer leaves become tough and leathery, and encircle and protect the younger leaves; this brings about a close packing of the young leaves, which are folded so as to be stowed away in a small space; hence their trifid form. The presence of stipules is always associated with a lobed form of the leaf, and they apparently assume their thread-like form to fill up a space which would otherwise be left empty in the bud.

The object of the paper on the placentation of the dugong, by Sir W. Turner, was to put on record the fact that the placenta of the dugong is zonary and *non*-deciduate; it differs, therefore, in the latter character from the elephant, and in the former from its near ally the manatee.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—The summary statement of lectures delivered during the past year shows that about ninety-five courses of lectures have been given in the subjects of the Faculty of Natural Science.

We may note the following among the lectures announced for this term:—

Prof. Sylvester will lecture on the resolution in integers of systems of linear equations with rational coefficients, and will reproduce an unpublished course of lectures given at King's College in 1869, on the relation of the theory of compound partitions of numbers to certain geometrical theories. Prof. Pritchard will lecture on planetary theory and on the Constellations.

Prof. Clifton, magnetism; Mr. Selby, the mathematical theory of electrostatics and magnetism.

Prof. Odling, diacidic olefine acids.

Prof. Green, stratigraphical geology and physical geology; Mr. Badger, palæontology.

Prof. Burdon Sanderson is unfortunately prevented from lecturing by serious illness, and Mr. Gotch and Dr. Haldane will lecture for him.

Dr. Tylor lectures on the development of religions, and Mr. Mackinder on the physical geography of the British Islands.

In the Medical Faculty, Mr. Thomson lectures on osteology, Dr. Collier on the methods of diagnosing disease of the heart, and Mr. Morgan on clinical surgery.

Scholarships and Exhibitions in Natural Science are offered for competition before Christmas by Balliol, Christ Church, and Trinity, and by Keble College.

Cambridge.—The Vice-Chancellor (Dr. Searle), in laying down his office, was able to relate that the executors of Mr. Newall had agreed to the conditions proposed to be made by the Senate as to the great telescope to be given to the University. The expense of transit, re-erection, and permanent work in promotion of stellar physics will be considerable.

The election of Mr. Jenkinson as Librarian gives the University an official who, in addition to his well-known classical and literary accomplishments, has no mean scientific qualifications. He was for some time Curator in Zoology, and is a member of the Botanic Gardens Syndicate and of the Council of the Cambridge Antiquarian Society. Men of science cannot regret Mr. Clark's retirement from the contest, for he literally could not be spared from the Museums, though otherwise highly qualified for the Librarianship.

There are very few new features in the science lectures this term. The list is, if anything, slightly longer, and would fill two of our pages; but there is nothing in it calling for special comment.

SCIENTIFIC SERIALS.

The *American Meteorological Journal* for September contains (1) an article by Prof. H. A. Hazen on cloud formation. The author considers that theories of storm generation and cloud formation are unsatisfactory. He has made a number of experiments, both with dry and damp air, on the formation of cloud by the cooling produced by exhaustion, the result being that he finds the amount of the latter to be only about one-fourth of what theory would indicate. The results obtained with dry and moist air were almost exactly the same. (2) State tornado charts for Alabama and Ohio, by Lieutenant Finley. (3) An article on the verification of weather forecasts, by H. Helm Clayton. He points out that all the methods adopted admit of considerable latitude in interpreting phenomena, so that the same forecasts, when verified by different persons, may differ widely as to the percentage of success, and he suggests an arrangement which may be applied to areas as well as to single stations, and which, at the same time, might be useful in studying the relative frequency of each phenomenon. (4) The distribution of wind velocities in the United States, by Dr. F. Waldo, deduced from the records of the self-recording anemometers at the stations of the Signal Service. In this article, which is unfinished, the author deals exclusively with the values of the constants derived from various anemometrical experiments in Germany and Russia.

The *Meteorologische Zeitschrift* for September 1889 contains a discussion, by Dr. J. Hann, of Parts iv. and v. of "Contributions to our Knowledge of the Meteorology of the Arctic

Regions," lately published by the Meteorological Council (see NATURE, vol. xxxviii. p. 625). He fully recognizes the value of this work, and the importance of a similar discussion of the observations collected during later expeditions. Dr. J. M. Pernter contributes an epitome of the Report of the Krakatão Committee of the Royal Society. Among the smaller "communications" may be mentioned (1) the description of a new registering apparatus for rainfall and wind, with electrical connections, in which the influence of the elements themselves is made to move the paper form, and the clock to record the indications, instead of the usual plan of the clock moving the paper (the principles of such an instrument were also referred to in the *Zeitschrift für Instrumentenkunde*, 1882, p. 206, and 1884, p. 300); (2) a note by Dr. Köppen, on the construction of isobars reduced to the level of 2500 metres, instead of to sea-level (the proposed plan is especially intended for use over large areas, where the differences of pressure and the altitudes of the stations are considerable, as, for instance, in Austria).

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 7.—M. Des Cloizeaux, President, in the chair.—Complement to the theory of thin weirs extending throughout the breadth of the bed of a water-course; approximate calculation, for depressed sheets, of the non-pressure at their lower face, according to the elevation of the surface down-stream, by M. J. Boussinesq.—New observations on the reciprocal displacements between oxygen and the halogens, by M. Berthelot. Fuming hydrochloric acid, in contact with air, does not yield chlorine, even after prolonged exposure to sunlight; but the addition of certain metallic chlorides (especially manganous chloride) causes it to react with oxygen, forming chlorine and water. This change is due to the formation and decomposition of a perchloride of manganese. Its bearing on thermo-chemical theory is pointed out.—On Raffinose, by the same. He describes a new hydrate, got by crystallization from aqueous alcohol, the formula being $C_{18}H_{32}O_{16} \cdot 6H_2O$ (the former one had $5H_2O$). Raffinose ferments wholly, with good beer-yeast. But with weak baker's yeast, the process stops, after forty-eight hours, when about a third has been affected. The raffinose seems to be broken up into a glucose, which ferments and disappears, leaving either a second sugar of the saccharose family, with a certain reducing power, or a mixture of two glucoses (one reducing).—Effects of an intermittent wind in soaring, by M. Marcy. A ball let off at the top of a board with sinuous profile, and descending series of heights, surmounts all those heights by gravity. Let off from the lowest height, it may be got back to the highest, if, each time it is rising, the board be jerked horizontally in the opposite direction. This experiment, suggested by M. Bazin, is applied to the case of the bird; an intermittent wind, acting as the bird rises, may enable it to gain height after each descent. (The movements of the ball M. Marey represents by photo-chronography.)—On transformism in micro-biology; limits, conditions, and consequences of the variability of *Bacillus anthracis*; researches on descendant or retrograde variability, by M. A. Chauveau. By continuous action of compressed oxygen on the *Bacillus*, one can obtain less and less resistant races or types, especially sensitive to the action of the attenuating agent, till at length they are found unable to vegetate in contact with it. Up to this limit, however, the *Bacillus* is pathogenic. It loses virulence, but keeps the vaccinal property throughout its existence. These new characters may be easily maintained by cultivation. And these special types of the *Bacillus* perhaps exist in nature.—On the invariants of certain differential equations and on their applications, by M. R. Liouville.—Determination of the difference of longitude between Paris and Madrid; an international research, carried out by MM. Esteban and Bassot. In 1863, MM. Le Verrier and Aguilar determined this difference indirectly, by measuring those between Paris and Biarritz, and Biarritz and Madrid. A direct determination was very desirable for geodetic purposes; and this, made with Brunner's portable meridian circles, and comparison of pendulums by chronographic inscription of telegraph signals (without relays) yields the value 24m. 6·00s. as against 24m. 6·08s. (Le Verrier).—On surfaces of which the ds^2 may be brought in various ways to the type of Liouville, by M. G. Kœnigs.—Synthesis of some oxygenated selenium compounds, in the aromatic series, by M. C. Chabrié.—Researches on fucusol, by M. Maquenne. This substance, obtained by Stenhouse from seaweed, proves to be a mixture of furfurol (10 parts) and methylfurfurol (1 part); the name should therefore be given up.—On the physiology of the trachea, by M. Nicaise. In normal, calm respiration, the trachea remains contracted, with unvarying diameter, the ends of the rings nearly in contact, also the borders. In strong respiration (shouting, singing, [&c.) the trachea dilates and elongates in respiration, the larynx rising; the reverse occurs in inspiration. He succeeded in registering these rhythmic movements. The dilatation is greatest at the upper part; it is permitted by the membranous portion, and is due to mechanical pressure of air. Compression of air by the dilated trachea plays an important part in singing, &c —On the pathology of nerve-terminations of muscles of animals and of man, by MM. Babes and Marinesco. By a new colouring method, they are able to follow the minute structure, and its alterations in atrophy, hypertrophy, segmentation, &c.—On a new *Proteromonas*, by M. J. Kunstler. This, found in the gray lizard of Gascony, is of S shape, and has a very long flagellum, two to five times as long as the body, starting usually from a globular enlargement. The name proposed is *P. dolichomastix*.—On the presence of pectic compounds in plants, by M. L. Mangin. These substances, he finds, play an important, if not preponderating *rôle* in the formation and growth of membrane; and he indicates methods of detecting their presence.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Habits of the Salmon: J. P. Traherne (Chapman and Hall).—On the Creation and Physical Structure of the Earth: J. T. Harrison (Longmans).—The Bermuda Islands: A. Heilprin (Philadelphia).—The Flora of Suffolk: W. M. Hind (Gurney and Jackson).—Steam-Engine Design: J. M. Whitham (Macmillan).—A Text-book on Steam and Steam-Engines, 5th edition: Prof. Jamieson (Griffin).—English Idyls: P. H. Emerson (Low).—Coloured Analytical Tables: H. W. Hake (Philip).—Manual of Orchidaceous Plants, Part 5: Masdevallia (Veitch).—A Life of John Davis, the Navigator: C. R. Markham (Philip).—The Science of Rights: J. G. Fichte: translated by A. E. Kroeger Trübner).—The Science of Knowledge: J. G. Fichte; translated by A. E. Kroeger (Trübner).—Chambers's Encyclopædia, new edition, vol. iv. (Chambers).—Wayside Sketches: F. E. Hulme (S.P.C.K.).—Diseases of Plants: H. M. Ward (S.P.C.K.).—The Zoo, 2nd series: Rev. J. G. Wood (S.P.C.K.)—The Story of a Tinder-box: C. M. Tidy (S.P.C.K.)—Time and Tide: Sir R. S. Ball (S.P.C.K.)

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THURSDAY, OCTOBER 24, 1889.

JAMES PRESCOTT JOULE.

THROUGHOUT the world of science there has spread a feeling of profound regret at the death of Mr. Joule, which was announced a week ago in the columns of NATURE. On the evening of the 11th of this month he passed away at his residence in Wardle Street, Sale, near Manchester. For many years past he was in very feeble health. Indeed, as long ago as 1872 it was known publicly that he was far from strong. In that year he was President-elect of the British Association, but before the time of the autumn meeting he was obliged to relinquish the honour on account of physical weakness; and Prof. Williamson was called upon to occupy the position. In recent years Mr. Joule was living in complete retirement, carrying on, so far as his health would permit, such observations and experiments as could be conducted without bodily fatigue; and during this period he was able to edit with occasional brief notes, the two volumes of his collected papers which have been published by the Physical Society of London. The first of these important volumes appeared in 1884, and was noticed in NATURE (vol. xxx. p. 27). The second was published in 1887 (see NATURE, vol. xxxv. p. 461), and contained the papers which Joule wrote jointly with Dr. Scoresby, Sir Lyon Playfair, and Sir William Thomson. At the end of the latter volume there is a list of no less than 115 contributions to the various scientific societies and journals which were enriched by communications from his pen. The papers of Joule are remarkable in form as they are in substance. Of mathematics there is scarcely a line; but they are models of clearness, of depth, and of penetration into the hidden things of Nature; and the mathematician finds the experimental results stated and arranged in such a manner as to lend themselves readily to representation in mathematical symbols. Of experimenting he was a perfect master—full of elegant device, and clear in mind as to points of difficulty and places where error might creep in. That which, in the hands of almost anyone else, would have proved too difficult to lead to a trustworthy conclusion, in his hands was often made to yield an important law or generalization, or to afford an accurate numerical result.

In NATURE (vol. xxvi. p. 617) there appeared a biographical sketch of Mr. Joule; a few words may, however, be permitted here, in order to fulfil our duty to one of the greatest scientific leaders of the present century.

His work, taken as a whole, and without considering the relative importance to physical discoveries—that is to say, judged by the originality of the objects, and the means employed, the philosophic direction, the patient and persevering labour, and the results obtained—would be such as to place him in the front rank of philosophers. If account be taken of the importance and generality of his discoveries, as shown by their influence on the philosophical thought and material progress of the world, then, as the discoverer of the law that energy is in the same degree as indestructible and uncreatable as matter, it is with Newton and Dalton that he finds his place in the history of physical science.

The law of the conservation of energy, which in all schools of science, even the most elementary, is now taught as the foundation of each and all the branches of physical science—mechanics, physics, and chemistry—was, in 1841, as far from recognition as at any time since the discoveries of Newton had shown that, in their observed motions, the heavenly bodies strictly obeyed the laws of motion. The properties of friction, internal and external, with which it was found necessary to endow terrestrial material, and which properties were apparently nothing less than those of destroying energy, were still as far from explanation as the property of gravitation itself; while the continued production in the steam-engine of energy from the same material by the agency of heat, without any consumption of heat, as was then not only supposed, but counted as proved by the equality of the heat received from the boiler and discharged into the condenser, showed apparently nothing less than the creation of energy.

The study of heat which had taken place in the meantime had done nothing to remove these difficulties, for the observed fact that heat was susceptible of quantitative measurement, independent of temperature, had led to the hypothesis that heat was an imponderable substance —"caloric"—capable of penetrating matter and altering its temperature and state, but neither creatable nor destructible. The discoveries of electric phenomena tended to strengthen the caloric hypothesis by affording another imponderable substance. Nor was it only such difficulties in the way of the acceptance of the conservation of energy which kept back its discovery.

Energy, as a measure of mechanical potency, had never assumed a prominent place in mechanical philosophy, while the action by which it is converted into motion against resistance, had scarcely been recognized as a general measure of mechanical action, so that when, as continually happened, the idea of heat being a mechanical action thrust itself forward, there was no distinct measure of mechanical action at hand in which to gauge the equivalent.

Outside the schools of mechanical philosophy engineers engaged in constructing and using the steam-engine had long been led to recognize motion against resistance as the mechanical and commercial measure of potency. Under the names "work" and "accumulated work," these men had become familiar with what are now known as work and energy (actual and potential). It may be noticed that Rumford first recognized the true nature of the relation between heat and mechanical action by observing that two horses working steadily produced heat at a steady rate, but he did not reduce his results further; while Joule was so familiar with the action work, that he never hesitated as to the nature of the relation.

It is true that at the time when Joule commenced his work, not only had mechanical philosophy, as applied to astronomy and such abstractions as frictionless and perfectly elastic matter, reached to nearly its highest level, but the other branches of physical science, studied independently, were fast approaching their present stages. Dalton's discoveries of chemical equivalents had been made thirty years before, and chemistry had been advancing by leaps and bounds. The phenomena of electricity had been subject to the masterly handling of

Faraday. The law of the motion of heat had not only been experimentally determined, but had been theoretically discussed by Fourier. The specific heats of the elementary bodies, as well as the heat developed in combination, had to some extent been determined by Dulong. And the law connecting the quantity of electricity produced in voltaic batteries with the number of chemical elements separated, had been discovered by Faraday. So far, however, these various branches of physics and chemistry had been subjects of separate and distinct study. No suggestion of equivalence had been made between the heat of combination of the elements and the electric current that would be produced by the same combination effected in the battery. That heat was developed in conductors by electric currents was known, but again there had been no suggestion of an equivalence between the heat and the resistancc overcome. What are now known as the dynamo and motor had been invented by Sturgeon, showing that work could be done by the agency of electricity and electric separation effected by the agency of work, but again no equivalence between the amount of work and the energy of combination of the element in the battery had been surmised.

It was for Joule not only to suggest all these equivalences, but to experimentally determine all their numerical values[1] before he came to the equivalence of the work[2] spent in overcoming fluid, or solid, friction and the heat produced; and, again, between the work spent in compressing air and the heat produced.

The discovery of the mechanical equivalent of heat, important as it is, is but a poor expression for the outcome of this work, in which Joule converted what had till then seemed unquestionable cases of the destruction of energy into the most striking cases of its indestructibility. And although he propounded no theory, but simply declared himself to have believed in the indestructibility of *vis-viva*, or living force, he had, in the truest sense of the word, discovered the universal law that energy is indestructible and uncreatable. As Joule's work came to be apprehended, this law became accepted as its natural consequence in greater and greater significance, until now it stands the most general recognized law in the universe; relating not only to all matter but also the medium of space, which is thus found to possess the mechanical properties of matter and to be subject to the laws of motion.

The discovery of this law, bringing as it does the several branches of physical science into the domain of mechanical philosophy, fitly crowned all the work in physical science of the previous 150 years, of which it was the result. It also opened out a fresh platform for further discoveries—a platform which was immediately occupied in the erection of the compound sciences of thermodynamics, electrodynamics, and the dynamical theory of gases.

Joule was never prominently before the public. Ready to give himself with absolute devotion to the cause of science and the advancement of human knowledge, he yet preferred retirement and the calm labour of his laboratory to the excitement of public lectures and demonstrations. While he was keenly alive to the sympathy of friends, yet he worked for the most part alone, or in conjunction with one or other of the friends mentioned in the earlier part of this notice. He sought not at all for fame, but only for truth.

And yet honours in plenty came to him. He received honorary degrees from the most important Universities; he was honorary Fellow of many learned Societies at home and abroad. He was a Fellow of the Royal Society, and received from it the Gold Royal Medal in 1852, and the Copley Gold Medal in 1870. The Albert Medal of the Society of Arts was delivered to him from the hands of the Prince of Wales in 1880. In 1878 he received a letter from Lord Beaconsfield, announcing that the Queen had been pleased to grant him a pension of £200 per annum. This recognition by his country of his life of scientific labour was a subject of much gratification to Mr. Joule.

Special reference may be made to his connection with the Literary and Philosophical Society of Manchester. This commencing, as it practically did, at the age of fifteen, when he studied chemistry under Dalton in the rooms of the Society, continuing, by the most regular attendance at all the meetings, so long as his health permitted, and practically terminating with his death, must have been one of the most important circumstances of his life. Elected a member in the year of his greatest discoveries, 1842, he was Secretary in 1846, Vice-President in 1850, which office he held till his death, except during the ten years when he was President. He took the greatest interest in the welfare of the Society, and secured not only the veneration but love of all the members.

A man of science who left so deep a mark on his age ought to have been buried in Westminster Abbey, but unfortunately the necessary application could not be made, in consequence of the delay in the public announcement of his death. Prof. Osborne Reynolds, President of the Manchester Literary and Philosophical Society, has written to the *Times* urging that a monument should be erected in the Abbey, and that steps should immediately be taken to obtain, if possible, the consent of the Dean. This suggestion ought to meet with cordial and unanimous approval. Joule's name is one of which Englishmen may justly be proud, and the erection of a monument in Westminster Abbey would be the most fitting way in which they could express their appreciation of the splendour of his contributions to science.

[1] Man. Lit. and Phil. Soc., 1841-43; *Phil. Mag.*, ser. 3, vol. xix. p. 200.
[2] *Phil. Mag.*, ser. 3, vol. xxiii.

THE LIFE OF SIR WILLIAM ROWAN HAMILTON.

Life of Sir William Rowan Hamilton. By Robert Percival Graves, M.A. Vol. III. "Dublin University Press Series." (Dublin: Hodges, Figgis, and Co. 1889.)

AT last the third and final volume of Graves's life of Sir William Rowan Hamilton has seen the light. It was our pleasure in former numbers of NATURE (vols. xxviii. p. 1, and xxxii. p. 619) to have reviewed the two earlier volumes, and we have now to congratulate the University of Dublin on the completion of an adequate biography of the most illustrious student that has ever issued from its halls. This present volume, of which we are now to speak, is as portly as its predecessors. It contains not less than 673 pages, and a very important feature of the work is the correspondence between Hamilton and De Morgan, which occupies more than half of the entire bulk.

The two earlier volumes described the career of Hamilton up to the year 1854. The great mathematician was then forty-eight years old, and the first of his two stupendous books on quaternions had been just published for the admiration and astonishment of the scientific world.

The abundant recognitions of the epoch-marking nature of this work were naturally extremely gratifying to its author. From numerous scientific Societies at home and abroad honourable distinctions poured in upon him. But we can readily comprehend the biographer when he tells us that Hamilton specially prized the tributes from such friendly and competent judges as Sir John Herschel and a few others of similar calibre.

It must, however, be recorded that those who expressed, and no doubt felt such admiration for the book had not always, as they themselves admitted, any very complete acquaintance with the subject. Herschel, for instance, says:—

"I got through the first three chapters of it with a much clearer perception of meaning than when I attacked it some three or four years back, but I was again obliged to give it up in despair."

Even though Hamilton and his intimate friend De Morgan corresponded for twenty-five years—even though De Morgan was himself a capable mathematician, whose labours led him in some degree towards the same line of investigation from which quaternions originated—yet he never succeeded in obtaining a competent acquaintance with Hamilton's theory. Most scientific men were apt to feel contented if they knew enough to make them reverence the awful volume which every mathematician likes to see on his shelves, but which we generally find that he likes to leave there.

It must be admitted that the hopes which Hamilton entertained as to the utility of quaternions as a mathematical calculus have not yet been fully realized. It seems to be the essence of modern mathematics that it should partake of the nature of exploration. For the furtherance of many departments of mathematics which are now ardently cultivated, a general and all-embracing calculus is not found so useful as are especial methods particularly contrived to the subject in hand. We may cite as an example of what we mean Klein's lectures on the Ikosahedron, which were so admirably reviewed in a recent number of NATURE (May 9, p. 35). The theory here involved may be regarded as typical of all that is best in modern mathematics; yet the methods which have been adopted are not those of any comprehensive calculus like quaternions; they are processes and lines of reasoning which naturally arise from the special character of the subject, and the same may be said with regard to other branches of mathematical research. Of course everyone admits the magnificence of quaternions viewed as a mathematical theory. It is indeed "a tract of beautiful country"; but, for the reason, apparently, that we have mentioned, it would seem that up to the present, at all events, the hopes which Hamilton entertained that quaternions should be largely used by mathematicians as a calculus have not been realized.

As to the value of quaternions we quote the following words of Prof. Tait, which occur in the preface of his well-known treatise on the subject, for probably there is no other living mathematician who could speak with equal authority:—

"The numerous examples I have given, though not specially chosen so as to display the full merits of quaternions, will yet sufficiently show their admirable simplicity and naturalness to induce the reader to attack the lectures and the elements; where he will find, in profusion, stores of valuable results, and of elegant yet powerful analytical investigations, such as are contained in the writings of but a very few of the greatest mathematicians."

The extraordinarily laborious habits of Hamilton are constantly referred to in this volume. He frequently speaks of working for twelve consecutive hours at mathematical research, and when immersed in these trances of discovery his regular meal hours were forgotten, and, unfortunately, he used to resort unduly to alcoholic stimulant. His relaxations, such as they were, may be conjectured from the following paragraph (p. 186) from a letter addressed to Dr. (now Sir Andrew) Hart by Hamilton the year before he died:—

"The fact is, that one of my early tastes was for metaphysics, and something has lately occurred to revive it. Another was for Eastern languages, and I chanced yesterday to light on the first sheet of a 'Persian grammar' written by myself forty years ago. These things, with others, may occasionally relax the bow—'*Non semper tendit*' but 'many tastes one power,' and my only *power* is mathematics."

As we have already stated, both the study of poetry and the writing of poetry were favourite recreations with Hamilton; and as this subject is so frequently mentioned in these volumes it may be well to mention what the biographer—himself an excellent judge—records on the matter (p. 128):—

"I will not here refrain from stating my own opinion, strengthened by that of friends specially competent to judge, that Hamilton's poems have, both in their diction and in their matter, qualities of enduring value; that, speaking generally, they are and will always be felt to be fresh, graceful, fervid expressions of states of feeling and thought, interesting in themselves and possessing a heightened interest from their being the heart's utterances of a man of gigantic mathematical powers and of strong and deep affections; and a few of them, it may be added, are so happy in thought and expression as to claim their place in the poetry of his country."

The closing years of Hamilton's life were spent in the preparation and the passing through the press of his second great volume, "The Elements of Quaternions." In the summer of 1865, his stupendous labours had at last reached their termination. His health, which had for long been failing, now gave way, and at last, from a complication of ailments, which included gout and bronchitis, he died on the 2nd of September, 1865.

An interesting chapter on the "characterizations" of Hamilton and his work closes the biographical part of the volume. A letter from Prof. De Morgan to Lady Hamilton (p. 215) contains the following passage:—

"I have called him one of my dearest friends: for I know not how much longer than twenty-five years we have been in intimate correspondence of most friendly agreement or disagreement, of most cordial interest in each other, and yet we did not know each other's faces. I met him about 1830 at Babbage's breakfast-table, and there for the only time in our lives we conversed. I saw him a long way off at the dinner given to Herschel about 1838, on his return from the Cape, and there we were not near enough, nor on that crowded day could we get near enough to exchange a word; and this is all I ever saw, and, so it has pleased God, all I shall see in this world, of a man whose friendly communications were among my greatest social enjoyments and greatest intellectual treats."

Hamilton was scrupulously sensitive about the feelings of others, and in his scientific work he took the most elaborate precautions that every particle of credit should be duly assigned to every mathematician whose labours had in the minutest extent anticipated his own. He had high personal courage and a keen sense of honour. It is recorded that he sent a hostile message to one who had challenged his veracity, and a due apology was exacted. The only approach that Hamilton ever had to a controversy about priority arose in the case of the discovery of conical refraction. MacCullagh put forward a claim to have virtually anticipated Hamilton. The sound judgment and lofty sense of right which were so characteristic of Humphrey Lloyd here averted what would have been an unpleasant dispute, and MacCullagh withdrew his pretension.

De Morgan says that in Hamilton's youth he used to be styled among his playmates the "defender of the absent," and from the same source we learn:—

"He relished the extremes both of simplicity and splendour; though in his own habits and manners as plain as possible, he thought much of the comforts of others and lightly of his own. When some housebreakers were caught on the premises and detained until they could be carried before a magistrate, he amused his family by directing that the fellows should be asked whether they preferred tea or milk for breakfast. A full memoir of his private and public life would present a genial combination of intellectual greatness, moral goodness, and piquant peculiarity of thought and manner, all brightened by never-ceasing benevolence of feeling, and toned by rare gentleness of manner."

Hamilton has left behind him an enormous bulk of manuscripts, of which not less than sixty great volumes have been deposited in the College Library. There are also many other papers unpublished, as, for instance, a stupendous letter to Dr. Hart, which contained about 240 large folio pages and a postscript of 60 additional.

The distinctive feature of this third volume of his life is the De Morgan correspondence, which, like the correspondence between Bessel and Olbers, will retain a permanent value. The opening letter of the series is from De Morgan, on May 8, 1841, in which he says: "I hardly know whether you remember that we made a little personal acquaintance some twelve years ago, when you were in London." The last is also from De Morgan, and the date February 3, 1865, relative to an application for a pension for the widow of the late Prof. Boole.

The correspondence, though largely on matters mathematical, ranges over a multitude of topics, classical and literary, logical and metaphysical, humorous and domestic. It sometimes glances at theology, occasionally condescends to refer to a practical question like the decimal system, but is almost wholly free from any reference to what are now generally known as the experimental or natural sciences, though we do indeed read of an electro-magnetic quaternion. From such an astounding mass of 400 pages it is difficult to cull passages which shall be regarded as samples. The collection is too heterogeneous to admit of such a process. It is, however, impossible not to feel how admirably the biographer has accomplished this part of his task. He has extracted from a mighty bulk of correspondence a collection so interesting that, after reading them through, we do not see any which we could wish to have been omitted.

It was three years after the interchange of letters had begun, and when Hamilton was thirty-nine years old, that De Morgan writes (p. 258):—

"I hope you are well, and taking care of yourself. Nobody gives you a good character in the second particular.

"The Astronomer-Royal in this country always lays down his work the moment he feels wrong, and plays till he feels right again. You have too much of our stock of science invested in your head to be allowed to commit waste. You are only tenant for life, and posterity has the reversion; and I don't see why you should not be compelled to keep yourself in repair."

Traditions of the state of Hamilton's study are still current. The awful masses of books and papers accumulated on the floor to such an extent that a lane had to be preserved for the perambulations of the Professor, who did much of his work standing at a blackboard, or walking up and down. Thus we can understand him writing to De Morgan on October 3, 1849 (p. 279):—

"If I lay a letter out of my hands for a few hours, without answering it, I am sure to find that it has been swept away and covered up, for the time, by the Charybdis of my other papers. No doubt, every such missing treasure may be expected, at some future time, to emerge to view, and may then be suddenly seized, by a bold and ready hand. Thus, from month to month, or at least from year to year, I find a note or two of yours eddying upward to the light; but, for the instant, your last long (and welcome) letter is invisible. However, I remember much of its contents, and shall send something now in answer to one, at least, of its 'loose thoughts.'"

As already mentioned, De Morgan could never be induced to devote himself sufficiently to quaternions to understand them. He often alludes to this, thus writing on October 11, 1849 (p. 283):—

"Nothing about quaternions will bore me, if I can only make it bore through me. Ink must be cheap in Ireland if you can afford to waste it on such a supposition as that."

Many amusing references are made by De Morgan to the contrast between his friendship to the Sir William Hamilton of Dublin, and his notorious controversies with the Sir William Hamilton of Edinburgh. Thus, on April 14, 1850 (p. 286):—

"Be it known unto you that I have discovered that you and the other Sir William Hamilton are reciprocal polars with respect to me (intellectually and morally, for the Scotch baronet is a Polar bear, and you, I was going to say, are a Polar gentleman, only I thought perhaps you might go and say I called you an Esquimaux). The intellectual polarity is of the kind, $\phi\psi(x) = -x$. When I send a bit of investigation to Edinburgh, the William

Hamilton of that ilk says I took it from him. When I send you one, you take it from me, generalize it at a glance, bestow it thus generalized upon society at large, and make me the second discoverer of a known theorem. He cuts my legs off; you make a pair of legs grow out of my head, and turn me upside down to stand upon them. His process after yours gives $\phi\psi(x) = -x$. Reciprocal polarity the last and most agreeable; your process involves no writing of pamphlets."

The gradual production of the books on quaternions are indicated by frequent allusions in the letters. On November 26, 1851, Hamilton writes (p. 291):—

"My book on the quaternions is advancing rapidly. I have just been correcting the slip which will bring it somewhat beyond 440 octavo pages. I first aimed at 200, but shall now congratulate myself if I get off under 500 pages. [It was ultimately 888.] You should be most welcome to copies of all the sheets hitherto printed, if I fancied that you would accept them, in the present state of the publication. In fact, I should *like* to send them, but think it not quite fair to *force* what may be thought a confidence on anyone."

To which De Morgan replies, in words that other authors will heartily appreciate (p. 293):—

"I beg you will send me the part printed, without scruple. There is a pleasure in reading while anything that strikes one may do service; it is the reviewer's feeling Christianized."

So much has been said about Hamilton's poems, and of the opinion he entertained of them, that it is well to read an authentic version of his own view of the matter in his letter of January 21, 1852 (p. 320):—

"If among your many and deep researches you have made psychology, as a sort of branch of natural history, one of them, you may feel some little interest in the following problem, which has often puzzled myself.

"Among the persons who know anything about my existence and my writings, I suppose that the majority would admit me to be a mathematician; while all, or nearly all, would say that I could only be regarded as a poet by courtesy.

"Does it not seem, then, to contradict one of the very tritest sayings about human nature that I care little, or not at all, about criticisms on my poetry, such as it is, while I own myself to be actually sensitive on the score of my mathematics?

"Wordsworth did me the honour to cut up, in a more slashing style than yours, some of my early poems. I think that I was less flattered than indifferent, although I did most highly prize the advantage of an intimacy with him.

"Slash away at my sonnets; but spare me, if you honestly can, a little praise for the quaternions, or, what will be far better, allow me the honour of *assisting* you to *use* them as a calculus, for such they certainly are."

Hamilton complains that he is ridiculed about the quaternions by people who know nothing of the method. De Morgan advises him to preface the book with a systematized body of results, on the ground that "every book should be provided with some palisade against mere talkers. . . . You will find the table of contents a useful outwork."

It would seem there was another class of quasi-scientific men of whom Hamilton, not without reason, had some dread, for we read (p. 360):—

"A story goes, that a person who read more than he digested once told a friend of his that he had heard people talk of 'Euclid,' and that he was curious to read the work. The other lent him a copy, and was surprised to find the borrower return it the next day with many thanks. 'What, have you read it?' said the lender. 'Yes, thank you,' replied the borrower. 'Read it?—read Euclid *through* in that short time?' 'Oh, if you mean the A's and the B's and the C's, I skipped all those.' The 'Quaternions' as well as the 'Formal Logic' may meet with some readers of that stamp."

To which De Morgan replies (p. 362):—

"When you tell the story about Euclid, remember that the man left out the A's and the B's and the C's and the pictures of scratches and scrawls. I once met a man, no strong mathematician, who said he read Airy's 'Gravitation' through on a bench in the front of his house."

We have learned in the earlier volumes of the almost miraculous talents which Hamilton displayed as a child for the acquisition of languages. It is therefore interesting to find him saying on April 16, 1852:—

"As to Sanscrit and Persian, I do not pretend to read them *now;* but my childish acquaintance with various languages may, as I have often since thought, have assisted me in my maturer study of mathematical symbols, and even in my attempts to enlarge the limits of mathematical expression."

An interesting letter to De Morgan on March 14, 1854, gives Hamilton's views on Auguste Comte's "Cours de Philosophie Positive," from which the following extract may be cited (p. 475):—

"These specimens, which I could easily multiply, may suffice to justify a profound distrust of Auguste Comte, wherever he may venture to speak as a mathematician. But his vast general ability, and that personal intimacy with the great Fourier which I most willingly take his own word for having enjoyed, must always give an interest to his *views* on any subject of pure or applied mathematics."

There were often long intermissions in the correspondence, generally on Hamilton's side, until at last De Morgan, by some genial and humorous attack, would succeed in reopening it. Witness the following:—

"If you are dead and buried, why can't you say so like a man, instead of leaving me to infer it from your silence."

And again on April 29, 1855 (p. 495):—

"Rouse out from the quaternions and write me a line. Remember that I, who have studied biography, and especially looked at the psychology of inventive mathematicians, do positively make affidavit, that if a man do not fallow, and shift courses, as they say, or used to say, in farming, he will put his head *out of heart.* If I had the power—supposing it true, as I hear, that you will not let quaternions alone for a while—I would put you into the commissariat, and make you copy out Balaklava stores, for six months. How are you all?"

These last lines remind us of a prescription recommended for another eminent mathematician, whose thoughts were apt to soar too far above terrestrial things. It was that he should serve for a couple of years as conductor to a London omnibus.

An appendix contains in the words of Hamilton himself what is designed to be as popular an account of the doctrine of quaternions as the subject will admit. It consists of two portions: firstly, an unfinished letter to his uncle, the Rev. James Hamilton, dated September 11

1846; the other an "elementary sketch," written after the publication of his volume of "Lectures on Quaternions." He here again insists on the combination of the notions of time and space in the quaternion.

> "And how the One of Time, of Space the Three
> Might in the Chain of Symbol girdled be."

The appendix also contains Hamilton's account of Mädler's attempt to show that the Pleiades are the central group of our sidereal system. The doctrine was unworthy of Hamilton's attention, and these pages are the only ones in this volume which we would gladly have seen omitted. Of infinitely more value are the remaining pages, in which we find a carefully compiled catalogue of all Hamilton's writings. There is also an interesting list of the chief unpublished manuscripts of Hamilton which have been preserved; and finally, before the capital index is reached, we have an enumeration, to which Prof. Tait has contributed, of the chief works of other mathematicians in which the quaternions have been employed.

It is impossible to read these volumes without acquiring a feeling of admiration amounting almost to reverence for the majestic intellect that they so adequately portray. In his youth Hamilton set before himself with deliberate aim the attainment of excellence in scientific work. Throughout his life he spared no pains, he flinched from no labour, to attain his ideal. With wonderful singleness and concentration he devoted his life to work. His career affords another illustration of the very close alliance if not actual identity between genius and the capacity for taking pains. If the quality of his work could not be surpassed, most assuredly its quantity could hardly be rivalled, and yet when we take leave of this work and ponder on the lessons it teaches it is perhaps hardly on the intellectual side of Hamilton's life that we shall find ourselves meditating. It is impossible to follow that exquisite correspondence between Hamilton and De Morgan without thinking of the rare but well-deserved good fortune which gave to De Morgan such a correspondent as Hamilton, which gave to Hamilton such a correspondent as De Morgan. On both sides these letters breathe a lofty spirit of truthfulness and honour and of attachment to whatsoever things are just and noble. Each shows a charming conception of the respect due to his friend and of the respect due to himself. Friendship such as these two men enjoyed was indeed a choice privilege. Hamilton shows himself not only as the consummate mathematician and philosopher, not only as the scholar and the poet, but as the high-minded gentleman with whom exalted conceptions of duty were habitual.

Finally, we must express our obligations to Mr. Graves for the admirable way in which he has completed his monumental task. He was intrusted with the preparation of the biography by Hamilton himself, and for laborious years he has devoted himself to the charge which his deceased friend laid upon him. Materials he had in abundance the most prodigal. He has selected copiously and he has selected judiciously, and he has told his wonderful story with a literary gracefulness that we most gratefully acknowledge. The memorable volumes of the "Lectures on Quaternions" and the "Elements of Quaternions" have a place on the shelves of all scientific libraries which are worthy of the name. Beside them should be ranged the three portly volumes in which Graves has recounted the life of that astonishing genius by whom Quaternions were invented.

THE ENGLISH TRANSLATION OF WEISMANN'S "ESSAYS."

Essays on Heredity and Kindred Biological Problems. By Dr. August Weismann. Authorized Translation, Edited by E. B. Poulton, Selmar Schönland, and Arthur E. Shipley. (Oxford: Clarendon Press, 1889.)

THIS is the fourth volume of a very useful series of translations of foreign biological memoirs, and the Delegates of the Clarendon Press are again to be congratulated on their choice of subject and editors.

As the editors' preface tells us, since Mr. Shipley's article, entitled "Death," in the *Nineteenth Century* for May 1885, first called the attention of English biologists to Prof. Weismann's essays, the interest in that author's conclusions and arguments has become very general. This interest has been stimulated and widened by the articles of various authors in NATURE, by Prof. Lankester's addresses at the Royal Institution, and, above all, by the great discussion introduced by Prof. Lankester at the meeting of the British Association in Manchester. No doubt a translation is superfluous, in these days of international science, to most biologists. But this is much more than a technical treatise on a technical subject. It is of interest to that far wider circle of readers and thinkers devoid of the time or the opportunity to wrestle with the involved German of the original. For to most the pith and kernel of the whole book is the criticism, perhaps the refutation, of the theory of the inheritance of acquired characters. That theory is of immediate importance to biology, but it is of equal, if remoter, importance to education and morality. We are certain that biologists do not enjoy a monopoly of education: we are by no means certain that they enjoy a monopoly of morality.

The translation is very accurate and unusually elegant: the foreign idiom has, to a large extent, been avoided, and there is little trace of the intricacies of Teutonic inversion. The footnotes are exceedingly useful, and many of them introduce important collateral matter. For instance, on p. 172, a concise and clear account is given of Mr. Francis Galton's earlier and somewhat parallel explanation of heredity.

The typography is excellent, but the absence of spaced type—a device of great utility in the original—is to be regretted.

The essays are translated in chronological order from the revised German editions. And so, by a consecutive perusal of the book, an historical conception of the wonderful series of inductions and inferences may be gained. Among the many converging lines of thought and work that led to the conception of the germ-plasma as the basis of heredity, two seem most clearly marked. In a prolonged study of the Hydromedusæ, Dr. Weismann discovered that the generative cells were formed only in certain localized areas. These special areas vary in position in different species, and the differences in position correspond to the different stages in a process of displacement occurring in the phylogeny of the Hydroids. In the actual development these stages are repeated, and the primitive germ-cells migrate from the ancestral to the present position. From this it followed that the germ-cells contained something *sui generis:* something that could not be derived from the tissue-cells.

The first and third essays, on the other hand, show how a more or less theoretical consideration of death as a factor in biology led to the establishing of an actual continuity of life from individual to individual in genealogical series. In all animals above those consisting essentially of a single cell, this continuity of life is confined to the generative cells, and it is the other, or somatic, cells alone that are necessarily mortal.

Such converging lines led to the provisional hypothesis of a continuity of germ-plasma as the basis of heredity—the hypothesis in fact, to take a simple instance, that it is the eggs that have been forming the hens, and not the hens the eggs, and so with their ancestors from the remotest of times. With this new view came the discussion of the inheritance of acquired characters and the brilliant interpretations and investigations of parthenogenesis and polar bodies. Essay VII., on the supposed botanical proofs of the transmission of acquired characters—which has not before appeared in any form in English—and Essay VIII., on the supposed transmission of mutilations, are valuable contributions to the questions raised by the general theory.

There can be no doubt but that Dr. Weismann's essays will be for long a source of inspiration and stimulus to supporter and adversary, and this valuable translation must prove of great service in making better known what, if it never advances beyond the stage of a provisional hypothesis, has already been of the utmost service to biology.

P. C. M.

OUR BOOK SHELF.

Chambers's Encyclopædia. New Edition. Vol. IV. (London and Edinburgh: W. and R. Chambers, 1889.)

In this volume of the new edition of "Chambers's Encyclopædia," subjects from "Dionysius" to "Friction" are dealt with. So far as we have been able to test it, we have found that the volume is in no respect inferior to its predecessors. The subjects include some that are of great scientific interest and importance, and these have been intrusted to writers whose names are a sufficient guarantee for the character of their work. Prof. Tait writes the article on force, Dr. W. Peddie those on energy and ether, and Prof. Cargill G. Knott that on electricity. Dynamos, the electric light, and the electric railway are described by Prof. J. A. Ewing. The theory of evolution is presented by Prof. Patrick Geddes, who, while expounding his own doctrine, tries to give a perfectly fair account of the opinions of thinkers with whom he only in part agrees. Dr. H. R. Mill has a good article on the earth, and Prof. James Geikie discourses with his usual clearness on Europe and on earthquakes. To the article on France, Prince Kropotkin contributes the geographical section. Prof. A. H. Keane is the author of the article on ethnology; and Dr. Henry Rink has a short but interesting paper on the Eskimo. These and other articles on scientific subjects in the present volume cannot fail to maintain the high reputation of "Chambers's Encyclopædia" for accuracy and thoroughness.

Farm Live Stock of Great Britain. By Robert Wallace, Professor of Agriculture at the University of Edinburgh. Second Edition. (Edinburgh: Oliver and Boyd. London: Simpkin, Marshall, and Co. 1889.)

This is a second edition of a work already reviewed in Nature. The most important point of difference between it and the first edition is the introduction of 100 excellent plates, executed by Angerer and Göschl, of Vienna, from photographs taken from life. Pictures are, no doubt, of great assistance to a description, but, as the author justly observes, photographs, although accurate, fail in some respects to do justice to animals. This he attributes to the awkward positions they assume while standing, and the constancy of their motion while they remain on their limbs. It is also, no doubt, partly due to the higher elevation of the eye of the observer than the camera as usually employed. The levelness of the back and of the belly lines is destroyed by the camera when placed horizontally so as to strike the broadside of the animal. Prominences are shown against the light, which in ordinary observation do not disturb the levelness of the carcass. The work has a strictly pastoral and agricultural interest.

Days with Industrials; or, Adventures and Experiences among Curious Industries. By Alexander H. Japp, LL.D. (London: Trübner and Co., 1889.)

This book is a reprint, with additions, of a number of articles which have appeared from time to time in various periodicals of a popular character. The articles deal with such subjects as quinine, rice, pearls, amber, common salt, Burton ale and Dublin stout, petroleum, canaries, bedsteads, railway-whistles, knives, forks, and postage-stamps—as heterogeneous a mixture, in fact, as the contents of Mrs. Jellaby's famous cupboard. Dr. Japp writes in a chatty and agreeable style, and his book may be safely given to young people, with the certainty that they will imbibe no false notions of science.

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.*]

Lamarck *versus* Weismann.

I had not intended to reply to Mr. Cunningham's criticism of a passage in my book which he thinks is pure Lamarckism (see Nature, July 25, p. 297); but now that Prof. Ray Lankester adopts the same view, I will make a few remarks upon the case. Mr. Cunningham italicizes the words, "the constant repetition of this effort causes the eye gradually to move round the head till it comes to the upper side," and claims this as a Lamarckian explanation. But if we italicize the following words, which occur three lines further on, "*those usually surviving whose eyes retained more and more of the position into which the young fish tried to twist them,*" we shall see that the survival of favourable variations is, even here, the real cause at work. For the transference of the eye to the upper side was a useful change—perhaps, under the peculiar conditions of existence and development—an absolutely essential one. The amount to which the eye could be twisted and retained in its new position was variable, as all other such characters are variable. Those individuals who had this faculty in the greatest degree were among those that survived, and it is not at all necessary to assume that any portion of the change *due solely to the effort* was inherited, but only that those individuals which were the most favourably constituted in this respect transmitted their peculiar constitution to their offspring, and thus the twisting would take place earlier and earlier in the development of the individual Even Darwin himself, who believed in the heredity of acquired variations, says that "the *tendency to distortion* would no doubt be increased through the principle of inheritance"; and this is really all that is necessary. In most of the higher animals symmetrical development of the two sides of the body is of vital importance, and is strictly preserved by natural selection; but more or less defect of symmetry often occurs as a variation or monstrosity, and in cases where such asymmetry was useful these variations would be preserved and increased by selection and heredity. An altogether erroneous view is taken of the fact of effort being used in this case, as if it were something unusual. But in all cases selection produces changes which are useful and whose use is often indicated by effort. The giraffe uses effort in stretching its neck to obtain food during a drought; the antelope exerts itself to the utmost to escape from the leopard; but it is now recognized that it is not the individual change produced by this *effort* that is inherited, but the favourable constitution which renders extreme effort unnecessary, and causes its possessors to survive while those less favourably constituted, and who therefore have to use greater effort, succumb. In the case of the developing flat-fish also, the effort indicated the direction of the useful modification, and any variations tending either to the right kind of asymmetry or to a mobility of the eye, admitting its being twisted and retained in its new position, during the growth of the individual, would be certainly preserved.

I wish to take this opportunity of thanking Prof. Ray Lankester for his careful and appreciative review of my book. I am too well aware of my own deficiency in training as a naturalist not to admit all the shortcomings which he so tenderly refers to. It is quite refreshing to me to read at last a real criticism from a thoroughly competent writer, after the more or less ignorant praise which the book has hitherto received. I admit also that the term "laboratory naturalist," to which he demurs, was not well chosen. I meant it as the opposite, not so much to "field naturalist" as to "systematic naturalist"; and it still seems to me that the gentlemen he refers to as not being "laboratory naturalists" are still less "systematic naturalists," in the sense of having specially devoted themselves to the observation, description, and classification of more or less extensive groups of species of living organisms. ALFRED R. WALLACE.

A Mechanical Illustration of the Propagation of a Sound-Wave.

HAVING to prepare some lectures on sound, I wished, if possible, to illustrate, without any very complicated apparatus, the way in which a sound-wave is propagated.

The following method suggested itself to me. As I have not met with the method while examining a large number of works on sound and wave motion, I venture to send a description of it to NATURE, as it may perhaps be of use to some students of acoustics.

A row of pendulums of equal length, *a*, *b*, *c* . . . *l* (Fig. 1) are suspended from a rod AB; in order to start the pendulums,

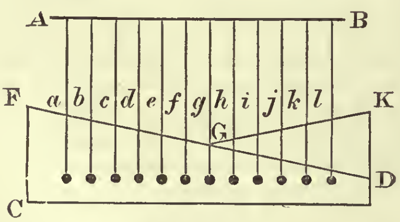


FIG. 1.

the bobs are held against an angular-shaped board, FCD, the rod being held in a plane slightly behind the plane of the board; if now the rod and pendulums be raised together vertically, *l* will first swing, then *k*, and so on, till all are free: when the pendulums are raised with a uniform velocity, then each pendulum starts at an equal period of time after the one which is next to it; the result is that a wave-motion is seen to run along the line of bobs as they vibrate to and fro. Such an arrangement has been used to illustrate wave-motion, as each bob moves with harmonic motion. But such an arrangement does not illustrate directly those compressions and rarefactions whereby sound is propagated. A slight movement, however, of the rod at once makes it do so. If, while the pendulums are vibrating, the rod from which they are suspended be turned in the horizontal plane through a right angle, the direction of the swing of each pendulum is not changed, and all the pendulums swing in the same plane. This will become clear from (Fig. 2), where the pendulum bobs viewed along OX appear to trace out wave-motion; the relative position of the bobs after the rod which supports them is turned through a right angle is shown along OY; the motion then illustrates mechanically those movements of air-particles which, when in compression and rarefaction, propagate a sound-wave. If the rod be turned back through a right angle, the wave-motion is again restored. The illustration must be taken with the obvious defect, viz. that the bobs move in arcs, and not in straight lines.

Care should be taken that the amplitude of vibration be not greater than the distance between the points of suspension minus

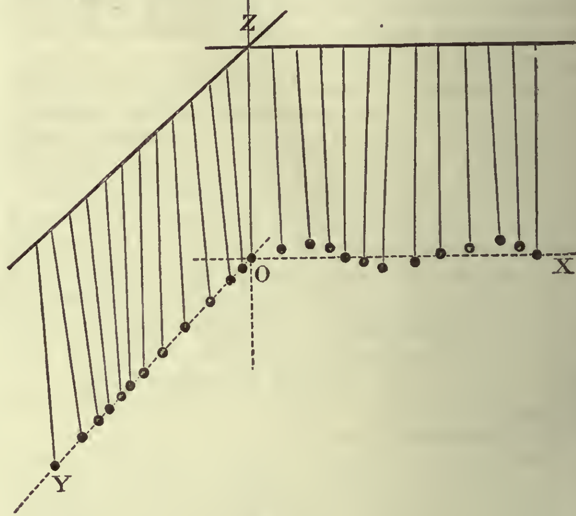


FIG. 2.

the diameter of a bob, otherwise the bobs will hit each other when vibrating in the plane YZ.

Twelve pendulums made of lead bullets 1·5 centimetre in diameter, suspended from threads 30 centimetres long, with a distance between each of 5 centimetres, were found to answer well by the author.

If the board used for starting the pendulums be made of the angular shape, FGK, then the movement of the bobs in their second position illustrates the propagation of sound on each side of its origin. FREDERICK J. SMITH.

Trinity College, Oxford, October 1.

On some Effects of Lightning.

THE twisting of one of the two trees near St. Albans, which were struck in such a remarkable manner by lightning, may well have been caused by the fall of the top of the tree, as Mr. Griffith suggests, and not directly by the lightning.

I have been unsuccessful in ascertaining whether the core of the tree is situated nearer that side where the explosion seems to have been most violent; but a more detailed examination only enforces the conclusion which Mr. Griffith and I arrived at, that the explosion must have occurred inside the stem, if not actually at the core of the tree.

The effects in this case can meet with no explanation from the supposition that the lightning passed between the bark and the tree, generating thereby sufficient steam to blow off the bark and shatter the stem—an explanation which Mr. Maclear suggests in his letter of September 25. I doubt if any source of heat would ever convert water so quickly into steam as to endow it with the power which dynamite has of shattering a hard object lying in contact with it, while the gases formed are restrained by the comparatively feeble resistance of the bark and outer air; nor can we suppose that sufficient heat could pass into the stem to generate steam there adequate for such an explosion, even if the uncharred condition of the wood did not prove incontestably that the temperature had not been raised very high. It seems more probable to me that such explosions must be caused by the lightning electrolysing the liquids in the stem, and thereby causing the sudden production of large volumes of gases at the ordinary temperature.

In answer to Mr. Griffith's query, I may state that the two trees are 34 yards apart; that there is no other tree in a direct line between them, though there are two about 4 yards from this line, and about midway between them; that the trees are certainly not isolated in any way, since there are fifteen trees within less than 34 yards of one of them, and about the same number within the same distance of the other.

48 Bryanston Square. SPENCER PICKERING.

Yew Trees in Berks.

A COMMUNICATION from Mr. Walter Money respecting two yew trees which were planted in the churchyard of Basildon, Berks, by Charles, Lord Fane, in 1726, has appeared lately in some of the papers (*North Wilts Herald*, October 4, 1889, and *Standard*), in which he refers to the dimensions recorded in the parish register, taken in 1780 and 1796, and again by my father in 1834. He adds his own observations on the growth taken this year. As I happen to have the original notes made by the late Prof. J. S. Henslow, dated "1834, August," it may be not uninteresting to record them. He writes as follows:—

"Measurements of yew trees at Basildon Churchyard, planted in 1726; taken near the ground:

		Ft.	In.	
Tree to south, 1780	... ...	6	3	According to Register.
1796	... ...	8	6	
1834	... ...	8	9	[J. S. H.]
,,	(at 4 feet)	6	$10\frac{1}{2}$	
[1889	... ...	9	10	Mr. Money]

Tree to north [1780 and 1796 not recorded in register]:

			Ft.	In.	
Roots lately injured by digging graves.	1834	... ...	9	$2\frac{1}{2}$	[J. S. H.]
	,,	(at 4 feet)	6	$9\frac{3}{4}$	
	[1889	... ...	9	6	Mr. Money]

"From the three observations of 1780, 1796, and 1834, it would appear that the period of rapid growth stopped about 1796; but it seems probable that the measurement here is somewhat too great compared with that of 1780, as well as with that of 1834; for

Growth to		Ft.	In.		Lines.		Lines.		Years.	Lines per ann.
1780	...	6	3	=	900	gives	300	diam. of gr. in	54,	*i.e.* $5\frac{1}{2}$
1796	...	2	3	=	324	,,	108	,, ,,	16,	,, $6\frac{3}{4}$

"Allowing this measurement to be wrong by 6 inches, it will reduce it to a greater probability also with that of 1834; and we shall have—

Growth to		Ft.	In.		Lines.		Lines.		Years.	Lines per ann.
1796	...	1	9	=	252	gives	84	diam. of gr. in	16,	*i.e.* $5\frac{1}{4}$
1834	...		9	=	108	,,	36	,, ,,	38,	,, 1
[1889	...	1	1	=	156	,,	52	,, ,,	55,	,, 1]

"N.B.—The increase between 1780 and 1796 is too great, supposing the same parts to have been measured; and between 1796 and 1834 it is too little; therefore 1796 either took in too much of the circumference of the roots, or perhaps 1780 a little above them. Possibly the soil had become somewhat raised since 1796.

[Since 1834 the growth for the last fifty-five years will be seen to be exactly the same per annum, or 1 line.]

[With regard to the rate of increase at a height of 4 feet from the ground, he adds the following additional note.]

"Now the rate of increase of 4 feet from the ground is slower than that near the root, upon the whole, in the proportion of one-fourth, nearly. Taking, therefore, this fact with the indications given above, we may average the growth of the stem at 4 feet in the following way:—

"Diameter at 4 feet = $\frac{990}{3}$ lines = 330 (in 1834). Dividing this by the age, or 108 years, it gives 3 lines per annum nearly.

"Also 1780 to 1796 gives 84 lines for 16 years, *i.e.* 5 lines per annum.

"As it seems not to have grown much in the last twenty-eight years (*i.e.* up to 1834), if we allow 1 line for this period, and distribute for the eighty years of rapid growth, we get the following result; thus:—

First 20 years at	$3\frac{1}{2}$ lines	=	70	Young growth.
,, 40 ,,	4 ,,	=	160	
,, 20 ,,	3 ,,	=	60	
,, 28 ,,	$1\frac{1}{2}$,,	=	42	Settled period."

GEORGE HENSLOW.

Maxwell's "Electricity and Magnetism."

THERE is apparently a trifling slip in § 360 of Maxwell's "Electricity and Magnetism." The ratio of the resistance of pure iron at 100° C. to the resistance at 0° C. is there stated to be 1·645. This ratio is evidently calculated from the results given in Matthiesen's paper on the influence of temperature on the electric conducting power of thallium and iron (Proc. Roy. Soc., 1862–63). The true ratio for pure iron annealed in hydrogen is 1·6255. The other ratios mentioned in the paragraph are correctly deduced.

HERBERT TOMLINSON.

King's College, Strand, October 12.

AN EXAMINATION OF SOME POINTS IN PROF. WEISMANN'S THEORY OF HEREDITY.[1]

PROF. WEISMANN'S views on heredity and allied phenomena have met with such general acceptance that I feel it to be presumptuous on my part to attempt any criticism of them. I cannot but think, however, that a statement of the difficulties which they present to me, and of the inconsistencies which appear to exist in the argument, may be of value, not indeed as a refutation, but as drawing attention to those points which seem to require further elucidation.

It will be necessary for me to state Prof. Weismann's argument, and I shall endeavour, in so doing, to represent it as fully and as fairly as my apprehension of it will admit, and as far as possible in his own words. But this is a matter of no small difficulty, inasmuch as the argument has to be traced through a number of separate essays, even though these essays have been collected into one volume and translated into English. All the references which I make relate to the English edition.[2]

The fundamental fact upon which the whole argument is based, and which Prof. Weismann appears to have fully established, is that the body of unicellular organisms (monoplastides), as also that of undifferentiated multicellular organisms (homoplastides), is immortal, at any rate potentially. This position is clearly stated in the following passage (p. 25):—

"The process of fission in the Amœba has been recently much discussed, and I am well aware that the life of the individual is generally believed to come to an end with the division which gives rise to two new individuals, as if death and reproduction were the same thing. But the process cannot truly be called death. Where is the dead body? What is it that dies? Nothing dies; the body of the animal only divides into two similar parts, possessing the same constitution."

Death is, on the contrary, a characteristic feature of differentiated multicellular organisms (heteroplastides); but even in these forms there is still an immortal part, for the reproductive cells which develop into new individuals are evidently as potentially immortal as the Amœba. In these higher organisms, therefore, the mortal cells are to be distinguished from the immortal. This distinction is drawn by Prof. Weismann as follows (p. 122):—

"It is necessary to distinguish between the mortal and the immortal part of the individual—the body in its narrow sense (*soma*) and the germ-cells. Death only affects the former; the

[1] This paper is an expansion of some remarks contributed to the discussion on "The Transmission of Acquired Characters," which took place in Section D during the recent meeting of the British Association at Newcastle.

[2] Weismann, "On Heredity" (Oxford: Clarendon Press, 1889).

germ-cells are potentially immortal, in so far as they are able, under favourable circumstances, to develop into a new individual, or, in other words, to surround themselves with a new body (*soma*)." (See also p. 158.)

This statement is further explained on p. 205:—

"Strictly speaking, I have therefore fallen into an inaccuracy in maintaining (in former works) that the germ-cells are themselves immortal; they only contain the undying part of the organism—the germ-plasm; and although this substance is, as far as we know, invariably surrounded by a cell-body, it does not always control the latter, and thus confer upon it the character of a germ-cell."

Similarly, the substance of the body is termed somatoplasm (p. 104). Moreover, the germ-plasm is stated to be localized in the nucleus of the germ-cell (p. 179).

The first difficulty which presents itself is to understand how the mortal heteroplastides can have been evolved from the immortal monoplastides or homoplastides. The explanation which Prof. Weismann offers is as follows (p. 27):—

"Let us now consider how it happened that multicellular animals and plants, which arose from unicellular forms of life, came to lose this power of living for ever.

"The answer to this question is closely bound up with the principle of division of labour which appeared among multicellular organisms at a very early stage, and which has gradually led to the production of greater and greater complexity in their structure.

"The first multicellular organism was probably a cluster of similar cells, but these units soon lost their original homogeneity. As the result of mere relative position, some of the cells were especially fitted to provide for the nutrition of the colony, while others undertook the work of reproduction. Hence the single group would come to be divided into two groups of cells, which may be called somatic and reproductive—the cells of the body as opposed to those which are concerned with reproduction. This differentiation was not at first absolute, and indeed it is not always so to-day. Among the lower Metazoa, such as the Polypes, the capacity for reproduction still exists to such a degree in the somatic cells, that a small number of them are able to give rise to a new organism—in fact, new individuals are normally produced by means of so-called buds. Furthermore, it is well known that many of the higher animals have retained considerable powers of regeneration; the salamander can replace its lost tail or foot, and the snail can reproduce its horns, eyes, &c.

"As the complexity of the Metazoan body increased, the two groups of cells became more sharply separated from each other. Very soon the somatic cells surpassed the reproductive in number, and during this increase they became more and more broken up by the principle of division of labour into sharply separated systems of tissues. As these changes took place, the power of reproducing large parts of the organism was lost, while the power of reproducing the whole individual became concentrated in the reproductive cells alone."

It is clear that this explanation, plausible as it seems to be, leaves untouched the real question at issue; the question as to how mortal cells could have been evolved from immortal. Prof. Weismann himself seems to have been conscious of this, for on p. 139 he reverts to the subject as follows:—

"It may be objected that cells of which the ancestors possessed the power of living for ever, could not have become potentially mortal (that is, subject to death from internal causes) either suddenly or gradually, for such a change would contradict the supposition which attributes immortality to their ancestors, and to the products of their division. This argument is valid, but it only applies so long as the descendants retain their original constitution. But as soon as the products of the fission of a potentially immortal cell acquire different constitutions by unequal fission, another possibility arises. Now it is conceivable that one of the products of fission might preserve the physical constitution necessary for immortality, but not the other, just as it is conceivable that such a cell—adapted for unending life—might bud off a small part, which would live a long time without the full capabilities of life possessed by the parent cell; again, it is possible that such a cell might extrude a certain portion of organic matter (a true excretion) which is already dead at the moment it leaves the body. Thus it is possible that true unequal cell-divisions, in which only one half possesses the condition necessary for increasing, may take place; and in the same way it is conceivable that the constitution of a cell determines the fixed duration of its life, examples of which are before us in the great number of cells in the higher Metazoa, which are destroyed by their functions. . . . But the reproductive cells cannot be limited in this way, and they alone are free from it. They could not lose their immortality, if indeed the Metazoa are derived from the immortal Protozoa, for from the very nature of that immortality it cannot be lost. From this point of view the body, or *soma*, appears in a certain sense as a secondary appendage of the real bearer of life—the reproductive cells."

Prof. Weismann here comes to closer quarters with the real question at issue, but still he does not fully face it. He invokes the principle of "unequal fission" to account for the acquisition of "different constitutions" by the products of fission, but he offers no explanation whatever of the *modus operandi* of unequal fission. He makes no suggestion as to the constitution of the body of the Protozoa; whether it consists, in his opinion, entirely of germ-plasm, and if not, whether or not the germ-plasm is localized in the nucleus. The only criticism which can be made is that the bare mention of "unequal fission" is not a sufficient answer to the objection "that cells, of which the ancestors possessed the power of living for ever, could not have become potentially mortal." It appears to me that any satisfactory answer to this objection must include the assumption that the immortal ancestors already contained a substance which was potentially mortal. It is impossible to conceive that unequal fission can take place in a cell consisting throughout of essentially the same kind of substance.

Very much the same difficulty presents itself in connection with the development of the embryo from the ovum or germ-cell; in the one case it is phylogenetic, in the other ontogenetic. Prof. Weismann goes into far greater detail in this latter case, and the statements which he makes concerning it may perhaps be intended to throw some light on the former.

The germ-cell, as pointed out above, is characterized by containing germ-plasm; and this germ-plasm is localized in the nucleus. There is one point which Prof. Weismann does not mention, and that is as to the nature of that portion of the germ-cell (including the cytoplasm and part of the nucleoplasm) which does not consist of germ-plasm. Of what, then, does it consist? It must consist of somatoplasm: there is no alternative. The germ-cell, then, consists mainly of mortal somatoplasm, and contains in its nucleus a certain amount of immortal germ-plasm. But, as shown in preceding quotations, Prof. Weismann holds that the whole germ-cell is immortal. In view of the constitution of the germ-cell, this view seems to be paradoxical, but it appears to be explained on the assumption that the substance of the nucleus determines the nature and character of the cell, though Prof. Weismann does not altogether commit himself to this assumption (see pp. 185, 205, 210).

From this point of view Prof. Weismann's suggestion that the development of mortal from immortal cells is due to unequal fission, seems to be quite intelligible, not only ontogenetically, but also phylogenetically, if we venture to assume that the constitution of a Protozoon is essentially the same as that of a germ-cell. It is easy to imagine that the nucleus of a Protozoon may be divided into two parts, one of which contains the whole or the greater part of the parental germ-plasm, the other containing none or only a small portion of it; the two resulting cells would be respectively immortal and mortal, and, supposing they remained coherent, would represent the reproductive and somatic portions of a heteroplastid body. Similarly, if such a division of the nucleus of the germ-cell took place, the two resulting cells would represent the reproductive and somatic portions of the body of the embryo.

But this does not appear to be Prof. Weismann's view of embryogeny. On the contrary, he holds strongly that the germ-plasm of the ovum gives rise, in part at least, to the somatoplasm of the embryo. Thus, on p. 168 he says:—

"I have called this substance 'germ-plasm,' and have assumed that it possesses a highly complex structure, conferring upon it the power of developing into a complex organism. I have attempted to explain heredity by supposing that in each ontogeny a part of the specific germ-plasm contained in the parent egg-cell is not used up in the construction of the body of the offspring, but is preserved unchanged for the formation of the germ-cells of the following generation."

It is not a little remarkable that Prof. Weismann should not have offered any suggestion as to the conception which he has formed of the mode in which the conversion of germ-plasm into somatoplasm can take place, considering that this assumption is the key to his whole position. He has been at considerable pains to controvert the view that somatoplasm may be converted into germ-plasm; but in making this attack he has overlooked the necessity for defence. There is really no other criticism to be made on an unsupported assumption such as this, than to say that it involves a contradiction in terms. The idea of the conversion of germ-plasm into somatoplasm is quite as impossible as that of the conversion of somatoplasm into germ-plasm. It is absurd to say that an immortal substance can be converted into a mortal substance. If such an apparent change takes place, the only possible conclusion is that the so-called immortal substance was never truly immortal, inasmuch as it must have always possessed the potentiality of mortality.

It may perhaps be represented that the foregoing criticisms are altogether of too minute and detailed a character to affect the general validity of Prof. Weismann's argument. My answer is that I understand Prof. Weismann to imply that his theory of heredity is not—like, for instance, Darwin's theory of pangenesis—"a provisional or purely formal solution" (Weismann, p. 166) of the question, but one which is applicable to every detail of embryogeny, as well as to the more general phenomena of heredity and variation.

We may now proceed to the consideration of Prof. Weismann's theory of heredity. The essential features of it are given in the following paragraphs (p. 73):—

"Among these unicellular organisms, heredity depends upon the continuity of the individual during the continual increase of its body by means of assimilation.

"But how is it with the multicellular organisms which do not reproduce by means of simple division, and in which the whole body of the parent does not pass over into the offspring?

"In such animals the power of reproduction is connected with certain cells, which, as germ-cells, may be contrasted with those which form the rest of the body; for the former have a totally different *rôle* to play; they are without significance for the life of the individual (that is, for the preservation of its life), and yet they alone possess the power of preserving the species. Each of these can, under certain conditions, develop into a complete organism of the same species as the parent, with every individual peculiarity of the latter reproduced more or less completely. How can such hereditary transmission of the characters of the parent take place? How can a single reproductive cell reproduce the whole body in all its details?"

Prof. Weismann's answer to these questions is as follows:—

"We have an obvious means by which the inheritance of all transmitted peculiarities takes place, *in the continuity of the substance of the germ-cells, or germ-plasm*. If, as I believe, the substance of the germ-cells, the germ-plasm, has remained in perpetual continuity from the first origin of life, and if the germ-plasm and the substance of the body, the somatoplasm, have always occupied different spheres, and if changes in the latter only arise when they have been preceded by corresponding changes in the former, then we can, up to a certain point, understand the principle of heredity; or, at any rate, we can conceive that the human mind may at some time be capable of understanding it" (p. 104).

"Now if it is impossible for the germ-cell to be, as it were, an extract of the whole body, and for all the cells of the organism to despatch small particles to the germ-cells, from which the latter derive the power of heredity; then there remain, as it seems to me, only two other possible, physiologically conceivable, theories as to the origin of germ-cells, manifesting such powers as we know they possess. Either the substance of the parent germ-cell is capable of undergoing a series of changes which, after the building-up of a new individual, leads back again to identical germ-cells; or the germ-cells are not derived at all, as far as their essential and characteristic substance i concerned, from the body of the individual, but they are derived directly from the parent germ-cell.

"I believe that the latter view is the true one. . . . . propose to call it the theory of the 'continuity of the germ plasm,' for it is founded upon the idea that heredity is brough about by the transference, from one generation to another, of a substance with a definite chemical, and, above all, molecula constitution. I have called this substance 'germ-plasm,' and have assumed that it possesses a highly complex structure, conferring upon it the power of developing into a complex organism. I have attempted to explain heredity by supposing that in each ontogeny a part of the specific germ-plasm contained in the parent egg is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation" (p. 167).

"I believe that heredity depends upon the fact that a small portion of the effective substance of the germ, the germ-plasm, remains unchanged during the development of the ovum into an organism, and that this part of the germ-plasm serves as a foundation from which the germ-cells of the new organism are produced. There is, therefore, continuity of the germ-plasm from one generation to another. One might represent the germ-plasm by the metaphor of a long creeping root-stock from which plants arise at intervals, these latter representing the individuals of successive generations" (p. 266).

This theory appears to fully account for the transmission and maintenance of ancestral characters; but of course it depends on the assumption that the germ-plasm is a substance of great stability. This is, in fact, Prof. Weismann's view (p. 271):—

"The germ-plasm, or idioplasm of the germ-cell (if this latter term be preferred), certainly possesses an exceedingly complex minute structure, but it is nevertheless a substance of extreme stability, for it absorbs nourishment, and grows enormously without the least change in its complex molecular structure."

In spite of the simple, and apparently satisfactory, explanation of the phenomena of heredity which this theory affords, there are, nevertheless, serious difficulties in the way of its acceptance. It is open to criticism even from Prof. Weismann's own standpoint. The fate of the germ-plasm of the fertilized ovum is, according to Prof. Weismann, to be converted in part into the somatoplasm of the embryo, and in part to be stored up in the germ-cells of the embryo. This being so, how are we to conceive that the germ-plasm of the ovum can impress upon the somatoplasm of the developing embryo the hereditary character of which it (the germ-plasm) is the bearer? This function cannot be discharged by that portion of the germ-plasm of the ovum which has become converted into the somatoplasm of the embryo, for the simple reason that it has ceased to be germ-plasm, and must therefore have lost the properties characteristic of that substance. Neither can it be discharged by that portion of the germ-plasm of the ovum which is aggregated in the germ-cells of the embryo, for under these cumstances it is withdrawn from all direct relation with the developing somatic cells. The question remains without an answer.

Still more is the theory open to criticism from the standpoint which I have established above. It is clear that the theory of the continuity of the germ-plasm, as explaining heredity, is only valid on the assumption that the germ-plasm of the ovum gives rise to the somatoplasm of the embryo. But I have shown above that the conversion of germ-plasm into somatoplasm is inconceivable; and, even if it be admitted, it cannot be seriously maintained that the whole body of the embryo is, in any case, developed solely from the germ-plasm of the ovum. On the contrary, since the embryo is developed from the *whole* of the nucleus and more or less of the cytoplasm of the ovum, it must be admitted that the non-germ-plasm, or somatoplasm, of the ovum provides a large part of the material in embryogeny. It is an obvious inference that, under these circumstances, hereditary characters may be transmitted from the parent to the offspring, not only by the germ-plasm, but also by the somatoplasm, of the ovum.

It might be replied to these criticisms that, even if it be admitted that germ-plasm cannot be converted into somatoplasm, and also that the somatic cells of the embryo are derived from the somatoplasm of the ovum, it is still conceivable that the nuclei of the somatic cells of the embryo may contain a certain amount of the germ-plasm of the ovum, not enough to confer upon the somatic cells the properties of germ-cells, but sufficient to determine their growth and differentiation in accordance with the hereditary tendencies of which the germ-plasm is the bearer. But this view does not appear to be held by Prof. Weismann, whose opinion with reference to the presence of germ-plasm in somatic cells is as follows (p. 211):—

"I believe I have shown that theoretically hardly any objections can be raised against the view that the nuclear substance of somatic cells may contain unchanged germ-plasm, or that this germ-plasm may be transmitted along certain lines. It is true that we might imagine *a priori* that all somatic nuclei contain a small amount of unchanged germ-plasm. In Hydroids such an assumption cannot be made, because only certain cells in a certain succession possess the power of developing into germ-cells; but it might well be imagined that in some organisms it would be a great advantage if every part possessed the power of growing up into the whole organism, and of producing sexual cells under appropriate circumstances. Such cases might exist if it were possible for all somatic nuclei to contain a minute fraction of unchanged germ-plasm."

After alluding to the fact that new plants can be developed from leaves of Begonia which have been cut off and laid in moist sand, Prof. Weismann continues:—

"But I think that this fact only proves that, in Begonia and similar plants, all the cells of the leaves, or perhaps only certain cells, contain a small amount of germ-plasm, and that, consequently, these plants are specially adapted for propagation by leaves. How is it, then, that all plants cannot be reproduced in this way? No one has ever grown a tree from a leaf of the lime or oak, or a flowering plant from the leaf of the tulip or convolvulus. It is insufficient to reply that, in the last-mentioned cases, the leaves are more strongly specialized, and have thus become unable to produce the germ-substance; for the leaf-cells in these different plants have hardly undergone histological differentiation in different degrees. If, notwithstanding, the one can produce a flowering plant, while the others have not the power, it is of course clear that reasons other than the degree of histological differentiation must exist; and, according to my opinion, such a reason is to be found in the admixture of a minute quantity of unchanged germ-plasm with some of their nuclei."

It appears, therefore, to be Prof. Weismann's opinion that it is only in special cases that germ-plasm is present in somatic cells, and that, when present, it confers on the somatic cells the properties of germ-cells, though it is difficult to reconcile this opinion with the following statement on p. 205:—

"Strictly speaking, I have therefore fallen into an inaccuracy in maintaining (in former works) that the germ-cells are themselves immortal; they only contain the undying part of the organism—the germ-plasm; and although this substance is, as far as we know, invariably surrounded by a cell-body, it does not always control the latter, and thus confer upon it the character of a germ-cell."

I would submit, therefore, that, inasmuch as Prof. Weismann offers no evidence to prove the continuity of the germ-plasm of the ovum with the somatoplasm of the embryo, his principle of the continuity of the germ-plasm cannot be regarded as a satisfactory theory of heredity; and I would point out that the facts of embryogeny seem to confer upon the idea of a continuity of the somatoplasm at least as high a degree of probability as upon that of a continuity of the germ-plasm.

We come, finally, to Prof. Weismann's explanation of variation, a connected statement of which is to be found on pp. 277 *et seq.*, from which I may make the following quotations:—

"The origin of hereditary individual variability cannot indeed be found in the higher organisms—the Metazoa and Metaphyta; but it is to be sought in the lowest—the unicellular organisms. In these latter the distinction between body-cell and germ-cell does not exist. Such organisms are reproduced by division, and if, therefore, any one of them becomes changed in the course of its life by some external influence, and thus receives an individual character, the method of reproduction insures that the acquired peculiarity will be transmitted to its descendants. If, for instance, a Protozoon, by constantly struggling against the influence of mechanical currents in water, were to gain a somewhat denser and more resistant protoplasm, or were to acquire the power of adhering more strongly than other individuals of its species, the peculiarity in question would be directly continued on into its two descendants, for the latter are at first nothing more than the two halves of the former. It therefore follows that every modification which appears in the course of its life, every individual character, however it may have arisen, must necessarily be directly transmitted to the two offspring of a unicellular organism" (p. 277).

"We are thus driven to the conclusion that the ultimate origin of hereditary individual differences lies in the direct action of external influences upon the organism. Hereditary variability cannot, however, arise in this way at every stage of organic development, as biologists have hitherto been inclined to believe. It can only arise in the lowest unicellular organisms; and when once individual difference had been attained by these, it necessarily passed over into the higher organisms when they first appeared. Sexual reproduction coming into existence at the same time, the hereditary differences were increased and multiplied, and arranged in ever-changing combinations" (p. 279).

"It is, however, obvious that sexual reproduction will readily afford such combinations of acquired characters, for by its means the most diverse features are continually united in the same individual, and this seems to me to be one of its most important results.

"I do not know what meaning can be attributed to sexual reproduction other than the creation of hereditary individual characters to form the material upon which natural selection may work" (p. 281).

In the essay entitled "On the Number of Polar Bodies and their Significance in Heredity," Prof. Weismann explains his conception of the mode in which sexual reproduction promotes variability, showing, with the assistance of diagrams, how the nuclear germ-plasm of a fertilized ovum contains germ-plasms derived from the ancestors of both parents.

The conception of the process of variation which the preceding passages (as well as others) produce in the mind of the reader is that unicellular organisms acquired, during the period of their entirely asexual reproduction, a number of individual differences; and that, since the appearance of sexual reproduction, these ancestral characters have been combined in an infinite number of ways, leading to the evolution of all existing varieties of plants and animals, to say nothing of all the varieties which have perished in the struggle for existence. It would, in fact, appear that Prof. Weismann denies the acquisition of any new individual characters due to the influence of external conditions by any except unicellular organisms.

This being his view, we find, as might be expected, that Prof. Weismann opposes the assumption of the transmission, by means of sexual or amphigonic reproduction, of characters which he terms "somatogenic" (p. 413); that is, of characters which have manifested themselves in the *soma* of an individual, not spontaneously, but as the result of the operation of external forces or conditions; and he critically sifts the evidence for such transmission with results which, it must be admitted, tell in favour of his views.

For all that, Prof. Weismann does not take up an altogether uncompromising position with reference to this point; in fact, his statements of opinion are so fluctuating that it is difficult to determine what his position exactly is: witness the following quotations:—

". . . and it is impossible to imagine any way in which the transmission of changes, produced by the direct action of external forces upon the somatic cells, can be brought about" (p. 80).

"Hence it follows that the transmission of acquired characters is an impossibility . . ." (p. 266).

"For the germ-cells are contained in the organism, and the external influences which affect them are intimately connected with the state of the organism in which they lie hid. If it be well nourished, the germ-cells will have abundant nutriment; and, conversely, if it be weak and sickly, the germ-cells will be arrested in their growth. It is even possible that the effects of these influences may be more specialized; that is to say, they may act only upon certain parts of the germ-cells. But this is indeed very different from believing that the changes of the organism which result from external stimuli can be transmitted to the germ-cells, and will re-develop in the next generation at the same time as that at which they arose in the parent, and in the same part of the organism" (p. 103).

"Still we cannot exclude the possibility of such a transmission occasionally occurring; for, even if the greater part of the effects must be attributed to natural selection, there might be a small part in certain cases which depends on this exceptional factor.

"A complete and satisfactory refutation of such an opinion cannot be brought forward at present; we can only point out that such an assumption introduces new and entirely obscure forces, and that innumerable cases exist in which we can certainly exclude all assistance from the transmission of acquired characters" (p. 100).

"If, on the other hand, acquired differences are transmitted, this would prove that there must be something wrong in the theory of the continuity of the germ-plasm, as above described, and in the non-transmission of acquired characters which results from this theory" (p. 268).

"It seems to me that the problem of the transmission or non-transmission of acquired characters remains, whether the theory of the continuity of the germ-plasm be accepted or rejected" (p. 403).

I would remark, with reference to the statement that it is impossible to imagine any way in which somatogenic changes can be transmitted, that such a transmission is quite conceivable, and is even probable, when the continuity of the somatoplasm is borne in mind. If the ovum contains somatoplasm, as we are driven to assume, and if, as cannot be denied, the somatoplasm takes part in the formation of the body of the embryo, then it is not impossible that changes induced in the body of the parent, by the action of external conditions, may be transmitted to the offspring through the somatoplasm of the ovum. The discontinuity of the somatoplasm must be proved before the impossibility of the transmission of somatogenic characters can be considered to have been established.

But if Prof. Weismann is not prepared to admit that there is more than a remote possibility that variation may, in some degree, be due to the transmission of somatogenic characters, he makes a large concession in admitting that new characters may be acquired in another way, and, being transmissible, lead to variation. The first hint of this view is to be found on pp. 98, 99:—

"These changes—such, for example, as are produced by a strange climate—have always been looked at under the supposition that they are transmitted and intensified from generation to generation, and for this reason the observations are not always sufficiently precise. It is difficult to say whether the changed climate may not first have changed the germ, and if this is the case the accumulation of effects through the action of heredity would present no difficulty" (p. 98).

"It must be admitted that there are cases, such as the climatic varieties of certain butterflies, which raise some difficulties against this explanation. I myself, some years ago, experimentally investigated one such case, and even now I cannot explain the facts otherwise than by supposing the passive acquisition of characters produced by the direct influence of climate" (p. 99; see also above quotation from p. 103).

It is again mentioned on p. 271, but it is not prominently asserted until p. 410, where Prof. Weismann says:—

"I have never doubted about the transmission of changes which depend upon an alteration in the germ-plasm of the reproductive cells, for I have always asserted that these changes, and these alone, must be transmitted. If anyone makes the contrary assertion, he merely proves that he does not understand what I have said upon the subject. In what other way could the transformation of species be produced, if changes in the germ-plasm cannot be transmitted? And how could the germ-plasm be changed except by the operation of external influences, using the words in their widest sense? . . ."

On pp. 402–403 Prof. Weismann defines his view more clearly:—

"It is certainly necessary to have two terms which distinguish between two chief groups of characters—the primary characters which first appear in the body itself, and the secondary ones which owe their appearance to variations in the germ, however such variations may have arisen. We have hitherto been accustomed to call the former 'acquired characters,' but we might also call them *somatogenic*, because they follow from the reaction of the *soma* under external influences; while all other characters might be contrasted as *blastogenic*, because they include all those characters in the body which have arisen from changes in the germ. In this way we might perhaps prevent the possibility of misunderstanding. . . . Among the blastogenic characters, we include not only all the changes produced by natural selection operating upon variations in the germ, but all other characters which result from this latter cause."

The point is again mentioned on p. 433:—

"It is therefore possible to imagine that the modifying effects of external influences upon the germ-plasm may be gradual and may increase in the course of generations, so that visible changes in the body (*soma*) are not produced until the effects have reached a certain intensity."

It is not a little remarkable that, after insisting so strongly, as in the passage previously quoted, on the extreme stability of the germ-plasm, Prof. Weismann should be prepared to admit that it is in so high a degree susceptible to the action of external influences. He is, however, inclined to complain, in the passage on p. 410, that this view of the production of blastogenic changes by external influences has been ignored; but the readers of the earlier essays may well be pardoned for inattention to this point, as it is only casually mentioned there, and is not put forward as an integral part of his theory of variation. No one reading the statement of his theory of variation on p. 277 would infer that Prof. Weismann attached any importance to the effect of external influences on the germ in producing new characters. In fact, Prof. Weismann himself seems hardly to realize how inevitable such a conclusion is. If it be admitted that unicellular organisms acquire new characters under the operation of external influences, it cannot consistently be doubted that this also takes place in germ-cells.

It seems to be necessary, therefore, to modify the conception of variation founded upon the above-quoted paragraph from p. 277, by introducing into it the operation of external influences upon the germ. We now see that though sexual reproduction greatly promotes variation in consequence of the ever-new combination of ancestral characters in each fertilization, yet another efficient cause of variation is the direct action of external influences on the germ, giving rise to blastogenic characters.

But this modified conception of the causes of variation comes into collision with Prof. Weismann's statement (p. 277) that "the origin of hereditary individual variability cannot indeed be found in the higher organisms—the Metazoa and Metaphyta; but it is to be sought for in the lowest—the unicellular organisms," a collision which is much to the detriment of the latter; for, if it cannot be denied that external influences give rise to blastogenic characters, then it cannot be maintained that "the origin of hereditary individual variability cannot be found in the higher organisms." On the contrary, it must be admitted that the modifying influence of external conditions continually affects not only unicellular organisms, but also the germ-cells of the Metazoa, producing new characters, thus inducing variation, in both.

This conclusion leads to the consideration of a point of great interest. In accordance with his view of the pre-eminent importance of amphigonic reproduction in causing variation, Prof. Weismann asserts the lack of variability in parthenogenetic forms, in the following words (p. 290):—

"If my theory as to the causes of hereditary individual variability be correct, it follows that all species with purely parthenogenetic reproduction are sure to die out; not, indeed, because of any failure in meeting the existing conditions of life, but because they are incapable of transforming themselves into new species, or, in fact, of adapting themselves to any new conditions. Such species can no longer be subject to the process of natural selection, because, with the disappearance of sexual reproduction, they have also lost the power of combining and increasing those hereditary individual characters which they possess."

The views contained in this paragraph appear to me to be completely at variance with the facts known concerning the Fungi, among plants. Thus, in the Saprolegnieæ, all the known forms, including several genera and many species, are parthenogenetic; the sexuality of the Ascomycetes is still the subject of discussion, but it is admitted that many genera and species of these Fungi are certainly asexual; and the sexuality of the Æcidiomycetes is extremely doubtful. These plants show no apparent tendency to die out, in spite of the absence of sexuality. But it may be replied that these families may be in the stage in which sexuality is just disappearing, and in which they are still adequately adapted to their conditions of life. Such an objection cannot apply, however, to the Basidiomycetes. These Fungi are not only entirely asexual, but it would appear that they have been evolved in a purely asexual manner from asexual ascomycetous or Æcidiomycetous ancestors. The Basidiomycetes, in fact, afford an example of a vast family of plants, of the most varied form and habit, including hundreds of genera and species, in which, so far as minute and long-continued investigation has shown, there is not, and probably never has been, any trace of a sexual process. How are we, then, to account for all the variation which has taken place in this group, quite independently of amphigonic reproduction? On this point Prof. Weismann says (p. 275):—

"If it could be shown that a purely parthenogenetic species had become transformed into a new one, such an observation would prove the existence of some force of transformation other than selective processes, for the new species could not have been produced by these latter."

It appears to me beyond doubt that, in the Fungi, new species have been developed from parthenogenetic forms, but I leave it to Prof. Weismann to suggest what "force of transformation other than selective processes" may have been operative.

It is not, however, argued that the variation of the higher Fungi is as great as it might have been had they possessed sexuality; for there can be no doubt that sexual reproduction does very materially promote variation. It seems probable, in fact, that the absence of sexuality in these plants may be just the reason why no higher forms have been evolved from them; for in this respect they present a striking contrast to the higher Algæ in which sexuality is well marked.

Since it is clear that new hereditary characters can be produced by the action of external influences on the germ, the outcome of Prof. Weismann's investigation of the phenomena of variation is that he has given prominence to the fact that new hereditary characters need not be apparent in the body of the parent, but that, on the contrary, the somatogenic characters are just those which are least likely to be transmitted. This is essentially the same position, though stated in more precise terms, as that taken up by Darwin, who held that it is not the sudden variations, due to altered external conditions, which become permanent, but those slowly produced by what he termed the accumulative action of changed conditions of life.

With this I close my criticisms, not because there are no other points which might be discussed, but because I have already touched upon many of them in my "Lectures on the Physiology of Plants" (Cambridge, 1886), and because I desire at present to deal solely with the more fundamental parts of the theory. I have, I think, said enough to show that, interesting and suggestive as is Prof. Weismann's theory of the continuity of the germ-plasm, it by no means affords, at least in its present form, so complete and ready an explanation of the facts of embryogeny, heredity, and variation, as the enthusiasm of some of his more ardent disciples would have us believe.

SYDNEY H. VINES.

Oxford, September.

NOTES.

WE regret to announce the death of Mr. John Ball, F.R.S., which took place somewhat suddenly at midnight on Monday last. We understand that the funeral will take place to-morrow (Friday), at 11 a.m., at St. Thomas's, Walham Green.

THE Reports of the Eclipse Expedition of 1886 are at length ready for publication, and will be issued immediately as separate numbers of the Philosophical Transactions. The first, "On the Total Solar Eclipse of August 29, 1886," is by Captain Darwin, Dr. Schuster, and Mr. Maunder; the second, "On the Observations made at the Island of Carriacou," is by the Rev. S. J. Perry; the third, "On the Determination of the Photometric Intensity of the Coronal Light," by Captain Abney and Prof. Thorpe; and the fourth, "On the Observations made at Grenville, in the Island of Grenada," by Mr. H. H. Turner.

THE collection of objects brought back by Prof. Haddon from various islands in Torres Straits is now to be seen in a part of the Eastern Assyrian room at the British Museum, on the upper floor of the north-east angle of the building. Special interest attaches to the anthropological specimens included in this valuable collection.

THE list of names to be recommended for the new Council of the London Mathematical Society at its annual meeting, on November 14, differs from that of last year in the following respect: the names of Prof. Cayley, F.R.S., and of Prof. W. Burnside will be submitted to fill up the vacancies caused by the retirement of Dr. E. J. Routh, F.R.S., and Prof. Hart, of Woolwich.

The Library of the Royal College of Surgeons will, as an experiment, be, for the remaining portion of the present year, open in the evening. On each week-day except Saturday the hours will be from 11 a.m. to 9 p.m.; on Saturdays the Library will be closed at 1 p.m.

A Physical Society is to be formed in Liverpool. It will hold its meetings at University College, and Prof. Oliver Lodge has consented to be nominated as first President. The preliminary meeting will be held in the Physics Theatre of University College, at 8 o'clock on Wednesday evening, November 6, Prof. Oliver Lodge in the chair. The Secretary (*pro tem.*) is Mr. Thomas Tarleton, 1 Hyde Road, Waterloo, Liverpool.

Mr. John W. McCoy, who died in Baltimore lately, bequeathed his library, with 100,000 dollars, to the Johns Hopkins University.

On Monday a statue of J. B. Dumas, the chemist, was unveiled at Alais, his native town, by M. Faye, French Minister of Agriculture.

Like many other schools, Fettes College, Edinburgh, has long been provided with chemical laboratories, but has had no room specially adapted for the teaching of physical science. This want has been met by the construction during the summer of a well-appointed physical laboratory fitted up both for lectures and for practical work by boys themselves. There is a well-arranged supply of gas and water, several stone slabs for delicate instruments affected by oscillations, screens for projection experiments, a heliostat window and system of blinds for darkening the room for experiments on light. A smaller room leading off from the main room is reserved for special work, and is also fitted up as a dark room for photography. The laboratory is close to the boys' workshop, and to the workshop of the resident carpenter and mechanic.

An interesting Report by Sir Brandford Griffith, Governor of the Gold Coast, has lately been issued by the Colonial Office. It describes at considerable length a tour through the interior of the colony, undertaken for the purpose of investigating the gold deposits and examining the gold-mines at work. The Governor comes to the conclusion that the country is rich in gold, and that it is merely a matter of the necessary time and scientific application for the metal to pay well for extraction. He finds, also, that "earnest and well-considered attempts" are now being made to secure success. An appendix containing a special Report on the Winnebah district and its mineral wealth is added.

At the first meeting of the new session of the Geological Society of Glasgow, Mr. John Young exhibited a fine series of specimens of Polyzoa and Monticuligrora, comprising over twenty species, which he had this summer discovered at Kirktonhelm, East Kilbride. He remarked that the shale which holds these organisms lies between the first and second Calderside limestones. Most of the specimens were taken from blocks of shale which had been partially burnt in the lime-kilns, the rock in its natural condition being of a gray colour, but changed by contact with heat into yellowish gray. From this change of colour the fronds of the Polyzoa, with their lace-like structure, stand out much more prominently than when the shale is in its original state. They have also the advantage of being very much hardened, whereas the shale is naturally very friable, decomposing almost whenever it is exposed to the action of the weather. Mr. James Bennie, of the Geological Survey of Scotland, read a paper, "Things New and Old from the Ancient Lake of Cowdenglen." Up to 1867 the picturesque little valley of Cowden, beyond Crofthead, on the road to Ayrshire, was not known to possess any features of special geological interest, but in that year, having been chosen as the route of the direct railway to Kilmarnock, it was invaded by the navvy with pick and shovel, to the utter destruction of all its natural beauties. The gradients being steep, the excavations were extensive, and at one point the bed of an ancient lake was cut through, containing deposits of mud and peat lying between two distinct layers of boulder clay. These stratified deposits were found to contain numerous remains of animal and vegetable life, both of higher and lower forms, and, as their presence afforded strong evidence of the great ice age, a controversy arose between the upholders of a single glacial period and those who believed in two or more. Of late years there has been a revival of interest in old lake deposits, which led the author to re-examine the subject and the specimens of the deposits in his possession. Always a supporter of the "interglacial" or successive theory of ice periods, he re-stated his case in the present paper, bringing forward a fresh accumulation of proof.

Messrs. King, Mendham, and Co., of the Western Electrical Works, Bristol, have sent us a sample of a very convenient pocket galvanometer which they are now making. It is about the size of an ordinary watch, the ring suspender acting also as a binding screw. It is not only a detector galvanometer, but can be used for the absolute measure of currents up to one ampere. The dial is accordingly graduated one half in degrees, and the other in milliamperes, and is so made that either half can be brought to the top whilst the needle remains in a vertical position. The front portion carries the dial and magnetic needle, and the back part of the case contains the bobbins wound with copper wire, the resistances of which have been measured and particulars furnished with the instrument. Small stands are also supplied for laboratory use if required. The instrument is beautifully finished, and we strongly recommend it to all who use batteries in any shape or form. To those who use electricity for medicinal purposes, where the current is of prescribed strength, such an instrument must be indispensable, and its importance to electric-bell fixers and telephone and telegraph worker is obvious. To economical users of batteries it will recommend itself, as many a good cell may be saved by the detection of the one which is really at fault. Full instructions are supplied with each instrument.

A good word has at last been said for the sparrow in America. In England this impudent bird is decidedly popular, but our kinsfolk in the United States consider him an unmitigated nuisance. Captain W. F. Segrave, British Consul at Baltimore, writing on the subject in a recent Report, warns the Americans that their policy in waging war against the sparrow may prove to be a mistake. "The great 'blizzard' of March 1888," he says, "destroyed multitudes of sparrows, and as a consequence, the past and present summers have seen a vast increase in grubs and caterpillars. Already in many large cities the inhabitants through the public press are complaining of the destruction of their ornamental trees, the diminished number of sparrows being unable to keep in check the vast increase which has taken place in noxious grubs, worms, and caterpillars."

The third and concluding portion of Prof. Kikuchi's (of Tokio) work on geometry has just reached us. It is entitled "Rittaikikagaku," or "Solid Geometry." He has not been able to derive assistance in its compilation from the work of the Association for the Improvement of Geometrical Teaching, as the syllabus of this subject is yet in an embryo state. If we may judge from the figures, he has adapted portions of Euclid xi., 1–21, and of Wilson's "Solid Geometry," with a brief treatment of the regular solids and the elements of spherical geometry. There is an appendix of the equivalents of English terms written in Japanese and Roman letters.

MESSRS. GURNEY AND JACKSON have in the press "A Handbook of European Birds," by James Backhouse, Jun. The author explains that, having frequently experienced the need of a handy reference volume on European birds, he has been at great pains to meet this want, by endeavouring to produce a complete series of short general descriptions, in a convenient form either for the portmanteau or the pocket. The work will be published by subscription during the autumn or early spring.

THE last published number (31) of *Excursions et Reconnaissances*, the official scientific and learned journal of the French possessions in Indo-China, contains the first of a series of articles, by M. Aymonier, the well-known scholar, on the writing, dialects, history, manners, and customs of the Chams, the ancient masters of Annam proper. The present instalment deals with the grammar, and is illustrated by some lithographs of their writing and their curious cursive alphabets. These are followed by a portion of a Romanized version, with a translation, in French prose, of an Annamite rhymed tragedy.

IN our abstract of the chemical papers at the British Association (p. 587) we gave an account of the paper on alloys read by Messrs. Heycock and Neville. These gentlemen send us the following expansion of our statement:—"(1) Our experiments lead us to the conclusion that the *molecule of aluminium when in solution in tin is* $Al_2 = 54$, and not, as stated, that its atomic weight is different from the accepted value. (2) We stated that the mere application of Raoult's method to alloys does not decide the molecular weight of metals in solution, because we have no standard molecule, of which the molecular complexity in solution is certainly known, to take as unity. By applying Van 't Hoff's theory of solution to alloys of tin, we calculate a number for the fall in the freezing-point produced by one *molecule* of metal in 100 molecules of tin which is almost identical with the constant fall found in our experiments for *one atom* of metal in 100 of tin. Hence we conclude that, with the exception of aluminium, and possibly indium, all the seventeen metals we have examined have single atom molecules when in solution in tin. Our experiments, therefore, in the main, confirm Prof. Ramsay's results obtained by another method, and E. Tamman's results with amalgam."

METHYL HYDRAZINE, $CH_3—NH—NH_2$, the simplest derivative of hydrazine or amidogen, $\begin{matrix} NH_2 \\ | \\ NH_2 \end{matrix}$, has been isolated by Dr. Gustav von Brüning in the Chemical Laboratory of the University of Wurzburg (*Liebig's Annalen*). It is a clear and very mobile liquid, boiling at 87° C., and possessing a most violent affinity for water, resembling in this respect the recently-isolated hydrazine itself. Its odour is very similar to that of methylamine, and the vapour produces a white cloud in the air due to absorption of moisture to form minute drops of the liquid hydrate. Brought in contact with water, it instantly dissolves with evolution of great heat. It reduces Fehling's solution in the cold, and decomposes nitrous acid with copious evolution of free nitrogen. Its hygroscopic character is so pronounced that it attacks the skin in a most painful manner, and rapidly destroys corks or caoutchouc stoppers. The mode of preparation finally adopted by Dr. von Brüning is in reality very simple, the only difficult operations being those involving its separation from water. It consists in first converting the mono-methyl derivative of urea, $CH_3—NH—CO—NH_2$, into the nitroso-compound, $CH_3—N(NO)—CO—NH_2$; this, upon reduction with zinc dust and glacial acetic acid, yields the corresponding hydrazine urea, which in turn is broken up by boiling with hydrochloric acid into carbonic anhydride, ammonia, and methyl hydrazine. In practice, 50 grams of nitrate of methyl urea are dissolved in warm water, and the solution cooled until crystals begin to form. Crushed ice is then added to keep the temperature as low as possible during the addition of the calculated quantity of solid sodium nitrite; the moment the nitrite is added, the nitroso-compound commences to separate in small yellow lamellæ, and may be obtained recrystallized from ether in much larger slightly yellow tables. The reduction of this nitroso body is then effected by suspending it in water and adding glacial acetic acid and zinc dust, the latter in small portions at a time, with constant agitation. The cold solution, filtered from excess of zinc dust, is then saturated with hydrochloric acid, and afterwards evaporated to a syrupy consistency. The syrup is next boiled for some hours with a concentrated solution of hydrochloric acid in a flask connected with an inverted condenser, after which the liquid is neutralized with a strong soda solution at a low temperature, and sufficient excess of soda added to redissolve the precipitated zinc hydrate. The alkaline solution is then distilled in steam, when the base rapidly and completely passes over, ammonia and methylamine escaping as gases. After removal of most of the dissolved ammonia and methylamine by boiling in the flask supplied with inverted condenser, the base is converted to its acid sulphate, $CH_3—NH—NH_2 . H_2SO_4$, and the crystals of this salt are distilled with a concentrated solution of soda containing pieces of solid sodium hydrate. The last trace of ammonia escapes, while the methyl hydrazine condenses in the cooled receiver. After allowing the distillate to remain in contact with solid soda for twenty-four hours, and then re-subjecting it to distillation, it is still found to contain water. It was, however, finally freed from water by heating to 100° C. in a sealed tube with anhydrous barium oxide.

THE additions to the Zoological Society's Gardens during the past week include a Pigtailed Monkey (*Macacus nemestrinus* ♂) from Java, presented by Mrs. Cosh; three Common Hedgehogs (*Erinaceus europæus*), British, presented by Mr. H. Pelham Curtis; two Cayenne Aracaris (*Pteroglossus aracari*) from Macey, Brazil, presented by Mr. Thomas Watson Permain; a Red and Blue Macaw (*Ara macao*) from Central America, presented by Mr. Robert Romer, Q.C.; a —— Hawk (*Asturina* sp. inc.) from Brazil, presented by Mr. J. E. Wolfe; a Well-marked Tortoise (*Homopus signatus*), a Rufescent Snake (*Leptodira rufescens*), three Smooth-bellied Snakes (*Homalosoma lutrix*), a Many-spotted Snake (*Coronella multimaculata*), a Cape Adder (*Vipera atropos*) from South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; two Macaque Monkeys (*Macacus cynomolgus* ♂ ♀) from India, deposited; six Indian Pythons (*Python molurus*), an Indian Cobra (*Naia tripudians*) from India, purchased.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *OCTOBER* 27—*NOVEMBER* 2.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on October 27

Sun rises, 6h. 48m.; souths, 11h. 43m. 55·9s.; daily decrease of southing, 4·9s.; sets, 16h. 40m.: right asc. on meridian, 14h. 8·0m.; decl. 12° 57′ S. Sidereal Time at Sunset, 19h. 5m.

Moon (at First Quarter October 31, 9h.) rises, 10h. 12m.; souths, 14h. 29m.; sets, 18h. 39m.: right asc. on meridian, 16h. 54·0m.; decl. 20° 49′ S.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	5 2 ...	10 40 ...	16 18 ...	13 4·4 ...	4 56 S.
Venus.....	4 6 ...	10 4 ...	16 2 ...	12 28·0 ...	1 16 S.
Mars......	2 38 ...	9 6 ...	15 34 ...	11 29·5 ...	4 46 N.
Jupiter....	12 0 ...	15 53 ...	19 46 ...	18 18·3 ...	23 29 S.
Saturn....	0 48 ...	7 54 ...	15 0 ...	10 17·4 ...	12 3 N.
Uranus ...	5 41 ...	11 2 ...	16 23 ...	13 26·4 ...	8 28 S.
Neptune..	17 58*...	1 47 ...	9 36 ..	4 9·1 ...	19 17 N.

* Indicates that the rising is that of the preceding evening.

Oct.	h.	
28 ...	23 ...	Jupiter in conjunction with and 0° 7′ south of the Moon.
31 ...	16 ..	Mercury at greatest elongation from the Sun, 19° west.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5 ...	81 17 N. ...	Oct. 30,	1 44	*m*
Algol	3 1·0 ...	40 32 N. ...	,, 27,	2 15	*m*
			,, 29,	23 4	*m*
U Monocerotis ...	7 25·5 ...	9 33 S. ...	,, 31,		*m*
R Cancri	8 10·4 ...	12 4 N. ...	,, 30,		*M*
U Ophiuchi... ...	17 10·9 ...	1 20 N. ...	,, 30,	21 36	*m*
X Ophiuchi... ...	18 33·1 ...	8 44 N. ...	,, 30,		*M*
β Lyræ...	18 46·0 ...	33 14 N. ...	,, 29,	20 30	*M*
			Nov. 2,	2 0	*m*
U Aquilæ	19 23·4 ...	7 16 S. ...	,, 2,	20 0	*M*
η Aquilæ	19 46·8 ...	0 43 N. ...	,, 2,	1 0	*m*
S Sagittæ	19 51·0 ...	16 20 N. ...	Oct. 29,	23 0	*M*
T Vulpeculæ ...	20 46·8 ...	27 1 N. ...	Nov. 1,	0 0	*m*
			,, 2,	2 0	*M*
δ Cephei	22 25·1 ...	57 51 N. ...	,, 1,	23 0	*m*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near ε Arietis	43° ...	22° N. ...	Slow; brilliant.
	55 ...	9 N. ...	,, ,,
,, χ Cancri	105 ...	12 N. ...	Swift; streaks.
	132 ...	22 N. ...	Very swift.

THE GEOGRAPHICAL PAPERS AT THE BRITISH ASSOCIATION.

SCIENTIFIC geography did not form a prominent feature in the Geographical Section at Newcastle. As was right and proper in so important an industrial centre, it was evidently intended to devote special attention to commercial geography. The success was only partial. It will have been seen that the President, Sir Francis De Winton, devoted a considerable part of his address to pointing out some of the important practical applications which may be made of geographical knowledge. Again, one of the ablest and most instructive papers read in the Section was by Dr. Hugh Robert Mill, on the Physical Basis of Commercial Geography. A *necessary preliminary*, Dr. Mill pointed out, to the study of commercial geography is a full acquaintance with topography, especially with the names and positions of all commercial towns. A *necessary accompaniment* to the study of commercial geography is a knowledge of the ever-varying relations between regions of supply and demand, the incidence of tariffs, and the political and social conditions of countries. The *physical basis* of commercial geography, which underlies and gives unity to the whole subject, is a knowledge of the resources of the earth as regards the various existing forms of matter and modes of energy, the best means of separating, combining, and modifying these so as to produce commodities, and the way in which commodities can be best transported. Commerce being the artificial redistribution of the matter and energy of the world, a knowledge of the general properties and the unchangeable laws of matter and energy should take a chief place in the training of commercial men. A general acquaintance with this practical science, which may be termed *applied physiography*, or *practical earth knowledge*, ought to be possessed by all merchants, and a special branch should be familiar to each. Amongst the advantages which would thus be gained are:—(1) The merchant would understand the principles of the production and manufacture of his goods. (2) He would know in many cases, without aimless and extravagant experiments, where it is possible to produce any special commodity in great abundance. (3) He could, to a great extent, anticipate the frequent changes in staple commodities by knowing what other commodities it is possible to produce in the regions now yielding the staple only. (4) He would understand the best and shortest routes between trade centres. Illustrations and arguments showing the importance of these statements were given in Dr. Mill's paper, and a large map of the commercial development of the world was shown. Dr. Mill has thus done something to give definite shape to a conception of commercial geography. The fact is, applied geography in general, like applied chemistry or applied physics, implies a sound knowledge of the subject as a science. If the facts and principles of the subject are thoroughly known, their application need not be difficult. This application cannot be said to have been very successful in Section E. The evident object in view was to exemplify by special examples the principles laid down in the President's address and in Dr. Mill's paper. Thus we had a series of papers on what purported to be the commercial geography of a number of countries or regions. The geography, however, in most cases was conspicuous by its absence. The papers were certainly most useful in their way, and doubtless would be of some commercial value. Thus Colonel Mark Bell's paper on the great Central Asian trade route from Peking to Kulja and Semrechensk, and to Yarkand and India, abounded with original information collected by an acute observer, and it is hoped will be published in full by the Royal Geographical Society. But the minute details dwelt upon by the author were quite unsuited to an audience. Mr. R. S. Gundry's review of industrial and commercial progress in China was admirable in its way, and the views enunciated by the author original and suggestive. The conclusion come to was that a more widespread desire for progress and radical financial reform will be required before China is likely to rival Japan in the completeness of its transformation.

There was as usual a considerable number of African papers, some of them really good even from the geographical standpoint. Governor Moloney gave much useful information on the Yoruba country and its various tribes, his paper, however, being mainly occupied with suggestions as to its industrial development. The same may be said of Captain Lugard's paper on Nyassaland, and Mr. Rankin's on the Zambesi. The Rev. R. P. Ashe's paper on Buganda contained little not already published in his recent work; it dealt mainly with the natives, their political organizations, their religion, manners, and customs. Captain E. C. Hore's paper on Lake Tanganyika was one of the best in the Section. The author, who has lived ten years on the lake, described its geographical position, as occupying the central depression of the heights of Africa, from the surrounding barrier of which descend the furthest sources of the great rivers; referred to its outlet, the Lukuga, and remarked upon certain earthquake phenomena, and the aspect of the depression and of the bed of the lake. He gave a general description of the lake, with the results of meteorological observations and notices of scenery, and aspects of the lake under various changes of weather. He described the natives living on the shores of the lake and within the central depression, as representing all the great African families, and gave some account of their arts and industries, and of the produce of the lake region. He sketched the African routes and lines of communication as converging towards or crossing the lake, and the present available approaches to the lake from the east coast. He then referred to the position of the lake amongst and in relation to present claims and operations in Central Africa, pointing out what European enterprise has already achieved on the lake.

An excellent paper in physical geography was that of Mr. Flinders Petrie on Wind-Action in Egypt, the results of his own recent observations in the Nile Delta. He stated that the underlying motions of the Delta are depression on the coast and upheaval at Ismailiyeh. Above these movements great changes have been made by wind-action; in some sites at least 8 feet of ground has been removed and deposited in the water. This has partly caused the great retreat of the Red Sea head, and tends to form the characteristic swamps of this district. Formerly the Delta was a desert tract, with valleys inundated by the Nile. Before historic times the Nile valley was deep in water, partly estuarine, partly fluvial, and great rainfall then took place. That this was in the human age is shown by the position of worked flints.

Mr. Batalha Reis, in his paper on recent Portuguese explorations in Africa, put in a claim for exploring activity on behalf of Portugal which it would be difficult to substantiate. Mr. E. G. Ravenstein made some important corrections in the course of the Upper Nile as laid down in recent German maps.

Mr. Basil Thomson's paper, on his recent expedition to the D'Entrecasteaux and Louisiade Islands, was the same as that given some time ago to the Royal Geographical Society, and reported in NATURE. Dr. Carl Lumholtz's paper, on the present and future of Queensland, was highly interesting and useful from a colonial point of view. He, moreover, gave some of the results of his own observations during the time he lived with the natives as one of themselves. He found them to be undoubted cannibals, and predicts their early extinction.

One of the most original and scientific papers in the Section was that of Dr. Guppy on the south coast of West Java. The author dealt with a part of Java which has not been much described. It is one of the least familiar portions of this large island, a circumstance due partly to its paucity of anchorages and to the difficulty in landing; partly to its having been allowed to become in some places a kind of menagerie; and partly, also, to the fact that it lies remote from the chief seats of government. Now that the Netherlands Indian Government are rapidly carrying out their systematic survey of the Preanger Residency, it will not be long before the south coast of West Java will be much better known than it is at present; and the recent extension of the central railway to Garoet and Tjirajap will do much to effect this end. The author's tracks over West Java would make a chequered pattern on a map; but he has thought it best not to refer to localities already well known—localities which are now yearly visited by hundreds of visitors. Taking the central railway as his base, he performed nearly all the distance on foot, walking about 560 miles in all. In the paper he endeavoured to give a general idea of this south coast alone. The huge volcanic cones were landmarks to him, and nothing more; they had been well described by Junker and others, so he resisted the temptation of climbing them, and reserved his main efforts for the examination of the little-described and remote south coasts of the Preanger and Bantam Residencies. The object he had in view was to ascertain what physical evidence there was for the belief that the west end of Java was originally united with Sumatra. In this paper the author showed that all the evidence on the Java side of the Sunda Strait points to the opposite conclusion. Zoological evidence cannot be held sufficient to establish the previous connection between two islands without the physical evidence of such a change. The problem, as usually stated, seems to begin at the wrong end of the matter. Given the present distribution of plants and animals, it is then attempted to explain the previous arrangement of the land, and this is done too often without appealing to the physical evidence at all. In tracing geographical changes in the past, it would seem more reasonable to adopt an opposite method; but in the great majority of cases affecting the distribution of animals, it would be wiser in the first place to assume the *status quo*, and fall back when that fails on the physical evidence of the presumed changes.

As was rightly pointed out by Mr. H. J. Mackinder, Dr. Guppy's apparent contempt of the argument from zoological distribution is to be deplored. Hitherto it has been regarded, and rightly so, by the ablest biologists and geographers, as one of the surest and most valuable keys to past geographical conditions; and it will require much more powerful arguments than Dr. Guppy was able to adduce in his paper to cast it aside.

In a paper on recent explorations in Peru and Bolivia, Mr. H. Guillaume described the efforts which have been made by Peruvian and Bolivian explorers and traders to open up the rivers and the dense forest country lying between them. Colonel Labre since 1872 has been endeavouring to open communication from the Purus to the Beni. He explored the River Itury and its affluents several times, as to the character and navigability of which he has contributed much new information. Padre Nicolas Armentia explored the Madre de Dios in 1885, and resided for some time in the country of the Araonas Indians. From its mouth for 280 miles the river receives no important tributary; the Padre believes it has a navigable course of 400 miles for steamers. Mr. Guillaume described in detail the gold-bearing region at the source of the Madre de Dios. He then referred to the explorations of Senor Carlos Fry on the Ucayli and its tributary, the Urubamba.

Mr. Theodore Bent's paper, on his recent visit to the Bahrein Islands in the Persian Gulf, was a contribution of some originality on the present condition, the antiquity, the inhabitants, and past history of this interesting group. Dr. Nansen's paper on Greenland was identical with that given to the Geographical Society, and already reported in NATURE.

The Report presented to this Section by Mr. Joseph Thomson, on the geography and geology of the Atlas Mountains, can hardly be said to contain anything that has not already appeared in his narrative, except the lists of plants and of Coleoptera.

On the whole, it will be seen that the Geographical Section has not a very brilliant account to render.

THE MECHANICAL PAPERS AT THE BRITISH ASSOCIATION.

AMONG the papers read in Section G, after the President had delivered his address, was one by Mr. Alex. C. Humphreys, on water-gas in the United States. Water-gas is produced by the decomposition of steam by incandescent carbon. The two ways of effecting the decomposition, the intermittent and continuous, were described. In the first a cupola furnace is used: a blast of air raises the fuel to the necessary temperature; when this is effected the air is cut off and steam turned on, the blowing in of air and steam occurring intermittently. In the continuous process, steam is passed uninterruptedly through retorts containing carbon, which are heated externally, or steam and air are forced in continuously through a cupola furnace; but the latter process has the disadvantage of the resultant gases containing nitrogen. Water-gas has no light-giving properties so that it has to be carburized for illuminating purposes, or employed to raise some solid substance to a white heat. The different processes in vogue were described, and their theory explained. In conclusion the author gave expression to the belief that the day of gas, fuel-gas, was rapidly approaching; that even the great rival of gas, the electric light, may yet be dependent on it for the cheapest means of producing the electric current. Then will the gas engineer and the electrical engineer, shoulder to shoulder, be striving to correct the present wasteful strains on Nature's storehouses.

Precautions to be adopted when the electric light is supplied by means of transformers, by Mr. Killingworth Hedges. In a paper the author read at the Southport meeting of the British Association, he urged the necessity of regulations, and the adoption of proper safety appliances, in connection with electric lighting. In this paper he refers to the danger incurred when currents of high tension are converted into pressures suitable for incandescent lamps by means of transformers. The precaution necessary in such cases is either to earth the secondary circuit—which, however, has certain disadvantages—or to connect one or both of the leads to a safety appliance, which would automatically divert any excess current to earth, and at the same time shut off the supply in that portion of the faulty circuit by the fusion of the lead wire or mica-foils in the main cut-outs. Numerous experiments have been made with a vacuum protector, designed by the author, to ascertain the distance which an alternating current of high E.M.F. will leap across the two electrodes, which were fixed in the opposite ends of a glass tube from which the air had been partially excluded. The results differ from those observed by De la Rue with continuous currents; the following phenomenon was noticed—that the arc, after starting between the two points, almost invariably extended itself to a bow-shape and ran back to the base of one or both of the platinum electrodes, one of which nearly always fused, leaving the other intact.

Electric launches on the Thames, by Prof. G. Forbes, F.R.S. Launches are chiefly wanted in the summer; to prevent injuries to banks the speeds should not be high, so that a comparatively small supply of accumulators is required. The author experimented with the *Delta*, 33 feet long, 6 feet beam, fitted with forty-four cells, weighing 2520 pounds. She is steered by a wheel in front within reach of three handles required to work her. The first is to put the current on or off; the second for half or full speed, and the third for going ahead or astern. The first is mechanically locked with the others, so that they cannot be moved without first cutting off the current. Fusible cut-outs are inserted to prevent injury to the motor if the propeller becomes jammed. The batteries are under the seats on each side of the boat, thus leaving clear space for passengers, of which she could carry twenty. The pull at full speed gives 1·44 horse-power, or 1074 watts, including electrical losses, slip, and all friction. The average pressure at the motor terminals during the run was 78 volts, and the average current 23 amperes, which gives 1794 watts expended. This gives a total efficiency of 60 per cent. The author suggested that negotiations should be opened with the Thames Conservancy to establish charging stations, as there was likely to be a great demand in the future for electric launches.

Series electrical traction (Northfleet Tramways), by Mr. Edward Manville, M.Inst.C.E. The economical distribution of electrical power over long distances involves the use of a current of high potential, and by running the motors in series the advantages of high potential are secured. The main features of a series electrical tramway are a dynamo producing a current of constant quantity, a closed metallic circuit of which travelling motors at all times form a part without ever being short-circuited, or having the current supply cut off from them, and the regulation of the power developed by the motor and absorbed by it without interrupting the continuity of the circuit. An insulated cable connected to one terminal of the generator traverses the whole length of the line, and is interrupted at distances of 20 feet, the divided ends being connected with the opposite faces of a "spring jack," which is at the same time the automatic switch and contact point. The current collector, which is the same length as and carried by the car, is constructed so as to pass between the faces of the "spring jack," and conduct the current to the motor without at any time short-circuiting it or interrupting the main circuit. In series running, there is little danger of damage to the motor by careless driving, or reversing while running; in descending a gradient there is positive advantage in checking the speed of the car by altering the field connections, so that the armature tends to revolve in the opposite direction to that in which the car is travelling; the power that would otherwise be lost in braking is thus added to that produced by the generator.

Telephonic communication between London and Paris, by Mr. W. H. Preece, F.R.S. The difficulty of such a communication was not the distance, 275 miles, between the two towns, as in the United States speech is maintained between New York and Boston, 350 miles apart; but the insertion of underground wires at each end, and of a cable in the middle, places difficulties in the way that have to be surmounted. The author has experimented on the cables between Dover and Calais and others, and finds the conditions to be fulfilled simple. The circuit must be metallic, the material copper, and the product of the resistance of the line and its capacity must not exceed 7500 for very good, 5000 for excellent, and 2500 for perfect speech. A circuit approaching as nearly as possible one between London and Paris was made on an artificial cable, and found to comply with the requirements.

On the purification of sewage and water contaminated with organic matter by electrolysis, by Mr. W. Webster. The paper was divided into four sections, of which the fourth referred to the use of the electric current. The fact that water and the salts contained therein are easily decomposed if the current is of sufficient intensity is the explanation of the whole system. The changes taking place in sewage when electrolyzed depend chiefly on the splitting up into their constituent parts of sodium, magnesium, and other chlorides, nascent chlorine and oxygen being set free at the positive and the bases at the negative pole.

The strength of alloys at different temperatures by Prof. W. C. Unwin, F.R.S. In 1877, the Admiralty made some experiments as to the effect of variation of temperature on the tenacity of copper, Muntz metal, and phosphor bronze, and found that up to 500° F. the tenacity diminished proportionately with increase of temperature; in the case of gun metal, on the other hand, the tenacity diminished regularly up to 300° to 350°, but beyond this temperature there was a sudden reduction in the strength, which was found to be as low as half that at ordinary atmospheric temperature, whilst at 500° it became *nil:* the gun metal tested consisted of alloys of copper, tin, and zinc combined in different proportions. The author determined to make a series of experiments, the results of which he brought before the Association. The various alloys used, which are tabulated below, were heated in an oil bath, the temperatures employed, being all below that of the boiling of mercury, were read by means of a mercury thermometer. The results were plotted on a diagram, and given in tables, and show that the decrease of tenacity follows a regular law in each case; the temperature was given in degrees Fahrenheit, and the tenacity in tons on the square inch.

Temperature.	Yellow brass.	Cast brass.	Delta metal.	Muntz metal.	Gun metal.	Phosphor bronze.
Ordinary Fahr.	24·09	12·45	31·16	24·68	11·66	16·06
400°	21·23	11·11	26·58	20·84	11·06	12·30
500°	18·33	7·69	23·83	18·81	7·84	11·11
650° about ...	14·40	3·23	16·04	17·15 (615°)	4·82 (600°)	8·17

The influence of variation of temperature on the ductility of the same alloys was also experimented on, and was found to vary with the different alloys; with brass and gun metal there was little elongation before fracture; with Muntz metal it was considerable. In these cases the ultimate elongation diminished with increase of temperature, but in the case of Delta metal it increased. These experiments are of a very important character, and were carried out by the author on account of the very high pressures, and therefore temperatures, at which modern steam-engines are worked.

Central station heating and power supply, by Mr. W. W. Phipson. The system consists in the constant circulation of water at high temperature and pressure (viz. 400° F. and 250 pounds per square inch) from boilers at the supply station, through supply mains covered with non-conducting material, and back to the boilers by means of return mains, the circulation being maintained by pumps. Service boxes to supply the houses are fixed under the footpaths, which are connected to the mains by an inch pipe. From these boxes the house supply is taken by means of copper pipes. A vessel, called a converter, is fixed inside the house, whose use is to permit the water to resolve itself into steam, the pressure of which is controlled by means of a reducing-valve fixed on the copper pipe, before it enters the converter. From this converter the house services are taken. If a supply of both heat and power is required, double or compound converters are used with two reducing-valves, the power being taken from one and the heat from the other.

A curve ranger, by Mr. Alex. P. Trotter. The instrument is an application of the twenty-first proposition of the third book of Euclid, viz. the angles in the same segment of a circle are equal. A half-silvered mirror, such as is used in sextants, is mounted on an axis at one end of a bar, the other being provided with a sight. The motion of the mirror on its axis allows its inclination to the sight to be adjusted. To set out a curve, a pole is set up at each extremity, and the mirror is suitably adjusted. When the poles are seen, the one direct through the unsilvered part and the other by reflection in the silvered part of the mirror in apparent coincidence, and in the middle of the field as shown by the vertical line engraved on the mirror, the instrument is then at the point on the curve required. The mirror being clamped in position, the observer walks in the direction of the curve, and at suitable intervals places himself so that the poles at the extremities of the curve are seen in apparent coincidence.

On the application of the transporting power of water to the deepening and improvement of rivers, by Mr. W. H. Wheeler, M.Inst.C.E. The object of the paper is to show that the transporting power of water may be applied to the proposed purpose, and that under favourable conditions this can be accomplished by breaking up shoals, or the natural bed of a river, by mechanical agency and by mixing the material with the water, and allowing it to be carried away to the sea or estuary in suspension. The author has designed an improved apparatus, which, whilst disintegrating the shoal, mixes its material with the water, allowing it to be effectively transported by the ebb current clear of the channel to be improved.

THE ANTHROPOLOGICAL PAPERS AT THE BRITISH ASSOCIATION.

THE work of the Section commenced on Thursday, September 12, by Mr. Francis Galton, F.R.S., reading a paper on the advisability of assigning marks for bodily efficiency in the examinations of candidates for the public services. In the recent report of H.M. Civil Service Commissioners, they state that, a scheme of competition for physical qualifications having been brought before the notice of the War Office, it was not accepted, on the ground that the authorities were "completely satisfied with the physique of the young men who came to them through our examinations." The marks, as at present, of the candidates whose places lie near the dividing line between success and failure, run pretty evenly; therefore it is contended that the State would obtain better servants if such moderate marks were allowed for physical qualifications as to insure the selection of the most efficient in body from among those who are nearly on a par intellectually.

Mr. Galton also read a paper on the principle and methods of assigning marks for bodily efficiency. Two separate considerations are involved in the just determination of a scale of marks, which are usually mixed up in unknown proportions. (1) Absolute performance—on the principle that if the daily output of one man is greater than that of another, he should be more highly paid, or marked, in that proportion. (2) Relative rank—on the principle that superiority, however small, insures success in competitions, and therefore the order of merit deserves recognition independently of the absolute amount of performance. The general conclusion is, that before proceeding to decide on scales of marks numerous measures should be discussed, made of persons of the same age and social class as the candidates, so that the quality of the men hereafter to be dealt with shall be statistically determined. The next step is to decide upon the relative weights to be allowed for absolute performance and for relative rank. Then, after a few other obvious preliminaries have been settled arbitrarily, consistent scales of marks could be at once drawn up.

A paper on left-leggedness, by Mr. W. K. Sibley, was read, in which the author contended that man is either naturally or artificially right-handed and left-legged, and, in walking, tends unconsciously to bear to the right; while the lower animals, on the other hand, appear nearly always to circle to the left. The left foot is more frequently the larger in the male than in the female sex, and the percentage of feet of the same size is greater in the female. The percentage of the right larger than the left is very constant, whereas the numbers of the left larger and those in which both feet are the same size are much more variable.

Prof. D. J. Cunningham read a paper on the occasional eighth true rib in man, and its possible relationship to right-handedness. In seventy subjects examined the anomaly occurred fourteen times, *i.e.* in 20 per cent. It was found twice in the male for every once in the female. Five cases were bilateral, nine cases were unilateral, and of these no less than eight exhibited the anomaly on the right side. From this Prof. Cunningham considered that it was just possible that the anomaly might have some connection with right-handedness.

The following papers were also read :—Dr. W. Wilberforce Smith, on the early failure of pairs of grinding teeth ; Dr. Ridolfo Livi, on the development of the wisdom teeth ; Prof. D. J. Cunningham, on the proportion of bone and cartilage in the lumbar section of the vertebral column in the apes and in different races of men. Prof. Cunningham also exhibited the model of the head of a man stated to be 106 years old, with the brain exposed, *in situ;* and the model of the head and shoulders of a young orang-utan, with the brain exposed, *in situ.*

On Friday, September 13, His Excellency Governor Moloney, C.M.G., read a paper on African airs and musical instruments. He distributed the airs geographically as follows :—A, Gambia ; B, Ewe or Dahomey ; C, Yoruba ; and D, Houssa. In the first division specimens were given of *Bambara, Mandingo,* and *Volof* melodies, while *Popo* and *Dahomey* airs illustrated section B. The *Yoruba* division included *Lagos, Ibadan,* and other airs, and reference was made to several *Houssa* melodies. These countries were topographically described, and brief reference was made to their musical instruments and to the native minstrels. The paper concluded with an explanation of what is known as the "*drum language.*"

Mr. Paul B. Du Chaillu read the next paper—the Vikings the direct ancestors of the English-speaking nations. The author described the early civilization and antiquities of the North-men, and dwelt upon the beauty of their ornaments and weapons, and also upon the similarity of Scandinavian and English ornaments belonging to the Early Iron Age, and the love of the Northern people for the sea. He spoke of the three maritime tribes of the North, according to the Romans, and of the fleets of the Sueones in the time of Tacitus ; of the expeditions of the so-called Saxons and Franks, and of the home of these tribes ; of the proofs from antiquities found in the North of the commerce of the North-men with the Roman Empire and with Greece ; and also pointed out that the tribes of Germania were not a seafaring people, and were uncivilized, according to Roman writers. He gave an account of the probable origin of the names "Saxon" and "Frank," and spoke of the early settlements in Britain by the North-men during the Roman occupation, and of how the name of England might have been given to part of Britain. He alluded to the different countries of the Jutes, and how the language of the North and that of England was similar in early times, and that England was always called by the North-men one of the Northern lands. He mentioned the English and Frankish chronicles, in which the Sueones, Danes, and North-men are described, and that neither Saxons or Franks were a sea-faring people either at the time of Charlemagne or at any earlier period, and he dwelt on the mythical settlement of Britain by Hengist and Horsa, given by the English chronicles, which is quite contrary to the Roman records, Sagas, and archæology, and concluded by expressing his belief that the North-men, or Vikings, were the direct ancestors of the English people.

Canon Isaac Taylor contributed further researches as to the origin of the Aryans. Since the Manchester meeting of the Association in 1887, when the author read a paper on the same subject, he had re-examined the whole question from the anthropological rather than from the philological point of view. Assuming that there had been no migration of any new race into Europe since the Neolithic period, he contended that anthropologists have established the existence in Europe of four distinct prehistoric races, which might be reasonably connected with four existing types, which occupied nearly the same regions as the four prehistoric races. We have (1) the tall northern dolichocephalic race, the Canstadt race of De Quatrefages, which is the Scandinavian race of Penka, and the Eguisheim race of other writers. The stature of this race amounted to 5 feet 10 inches. It was platycnemic, prognathous, and dolichocephalic, with a mean cephalic index of from 72 to 73. The only pure descendants of this race are the North Germans and the Swedes. This Scandinavian or North-German type is maintained by Penka and other German writers to represent the primitive Aryans, who conquered the other European races and imposed on them their own Aryan speech. (2) We have a second type, also dolichocephalic, called the Silurian type by Prof. Rolleston, which is found in the long barrows of England. The normal stature was short, averaging 5 feet 4 inches ; 6 inches less than that of the other dolichocephalic race. The cephalic index is between 73 and 74. This race was orthognathous, and swarthy, with dark curly hair, oval face, and feeble muscular development. It is now represented by the Welsh of Denbighshire, by the Irish of Kerry and Galway, by some of the Scotch clans, by the Spanish Basques, the Corsicans, the Sicilians, the Berbers, and the Guanches of the Canary Islands. (3) We have a tall northern brachycephalic race, represented in the round barrows of the Bronze Age in England, in the tumuli of Denmark and some caves of Belgium. The average stature was 5 feet 8½ inches, the mean cephalic index was 81. It was macrognathous—with projecting teeth and powerful jaws, a square powerful chin, and a face quadrangular rather than oval. It is almost certain that the hair was light, either red or reddish-yellow. It was, in all probability, the race which introduced Celtic speech into England, and is now represented by the tall, yellow, freckled Irish, by some Highlanders, by the Danes, and most of the Slaves, by the Esthonians, and by many Finno-Ugric tribes. (4) The fourth prehistoric race was also brachycephalic, but short in stature. It never penetrated to England, but is represented in the sepulchral caves of the Lesse in Belgium. The stature was from 5 feet to 5 feet 3 inches ; the mean cephali index was 84 ; it was orthognathous and acrocephalic. It is now represented by the short dark population of Central France, more especially by the Auvergnats, the Savoyards, and the French Basques. It is found in the Rhætian Alps and among the Lapps. The hair is black and straight, and the eyes are dark. These four types and no others appear to have occupied Europe in the Neolithic period. It is difficult to find for them unexceptionable names, but we may for convenience call the first the Scandinavian type, the second the Silurian type, the third the Slavic type, the fourth the Auvergnat type. We have to determine which of these four races was probably the original Aryan race. The primitive Aryans must have either been by race Scandinavians or Slavo-Celts, and one must have imposed Aryan speech on the other. The Celts seem to have been in a higher stage of culture than the Germans, and therefore it is more probable that the Celtic race Aryanized the Teutonic race than that the Teutonic race Aryanized the Celtic race. Two hypotheses are possible—either the human race originated in Europe, bifurcating into the African and Asiatic races ; or we may suppose the white or European race to have originated from the union of the yellow race of Asia and the black race of Africa.

Canon Taylor also read a paper on the ethnological significance of the beech. While the Latin *fagus* and the Gothic *boka* denote the beech, the word has come to mean the oak in Greek. The author endeavoured to show that the word *fagus* originally denoted the beech and not the oak, also that the Greeks entered Hellas from the north-west. The range of the beech is limited. It is a lover of chalk soils, and does not grow east of a line drawn from Königsberg to the Crimea. West of this line we must therefore put the cradle of

Latin, Greek, Celtic, and Teutonic peoples, as they had the same name for the tree prior to their linguistic separation. The Lithuanian and Slavonic tongues must have originated east of this line, as their name of the beech is a loan-word from the German. The early home of the beech seems to have been limited to France, Central and Southern Germany, Northern Greece, and Northern Italy. If, as has been contended, the cradle of the European Aryans was in Central Asia, where the beech is unknown, it is difficult to explain how the ancestors of Celts, Latins, Greeks, and Teutons migrating, at different times and by separate routes, to lands where the beech abounds, should have called it by the same name, modified in each case by the fundamental phonetic laws of the various languages. It is easier to believe that the cradle of the Aryans was, so to speak, astride of the beech line, the ancestors of Celts, Latins, Greeks, and Germans living to the west of it, and those of the Lithuanians and Slaves further to the east.

In a paper by Mr. Hyde Clarke, on the right of property in trees on another's land, as an origin of rights of property, the author stated that his attention was first called to the subject, as a Land-judge or Commissioner in Asia Minor, in 1862, in granting compensation for olive-trees belonging to one or more individuals on the fields of others, and for honey-trees or hoards of wild honey in State or Communal forests. The author had found evidence as to the existence of the custom in Borneo, with regard to Tapang or honey-trees, and in Chota Nagpore as to the Mhowa, a tree furnishing food, spirit, oil, &c. In China a lessee has the right to bamboo, &c., grown by him. The practice in the Turkish Empire he found extended into the European provinces, as applied to plum-trees in Bosnia. In Ireland it was recognized in the Brehon Laws as an individual property separate from tribal property. It is probable that the personal right of the first discoverer of honey and similar trees is to be regarded as the origin of an individual right of property rather than any right in land, which is of no value in a primitive community. Even cultivable land belonged to the community, and was distributed by lot yearly.

A paper by the Rev. J. Wilson, on an hypothesis of a European origin of early Egyptian art, was also read.

On Monday, September 16, Dr. Garson exhibited an anthropometric instrument specially designed for the use of travellers. This instrument occupies very little space, and its weight is scarcely more than that of a detective camera. It can be used for taking all measurements of length and diameter with ease and accuracy.

Mr. Francis Galton, F.R.S., exhibited an instrument for measuring the reaction time to sight and sound signals, and explained that they heard much about the quickness of hand and eye. When anyone saw or heard a thing he made a movement, and between the sight and the movement many physiological processes took place so quickly that the flash of lightning was nothing to it. The instrument he exhibited was intended to make an accurate measurement of the time which elapsed between the seeing or hearing of anything and the time occupied in making a certain movement afterwards.

Dr. Thomas Wilson gave an account of the Smithsonian Institution in the United States of America, and its work relating to anthropology.

In a paper by Dr. MacLaurin, on the British race in Australia, the author said that he did not think there was any distinct type of configuration in the Australian-born inhabitant which was sufficient to distinguish him from the ordinary Englishman, Scotchman, or Irishman. The muscular vigour of the British Australian race could be estimated by the readiness with which it entered into athletic exercises, and the result of this had been evident in the number of sculling champions and cricket teams that had recently visited this country. The population was increasing through the excess of births over deaths, which showed that the vitality of the race had not been diminished by transplantation to Australia.

Mr. H. H. Risley next read a paper on the study of ethnology in India. It was shown that the population of Northern India comprised three distinct types, viz. :—(1) A leptorhine dolichocephalic type of tall stature, fair complexion, and high facial angle, apparently corresponding in all points, except hair and complexion, with the Aryan type as defined by Herr Karl Penka, of Vienna. (2) A platyrhine dolichocephalic type of low stature, black or very dark complexion, and low facial angle. The wider racial affinities of this type are uncertain, and it is tentatively and conjecturally described as Australioid. (3) A mesorhine, platyopic, brachycephalic type of low stature, yellowish complexion, and low facial angle, described, in virtue of its low naso-malar index, as Mongoloid. The types thus worked out by anthropometric methods were shown to correspond with certain ethnographic groupings independently ascertained. In the Aryan and Australioid types the social status of each caste or tribe is found to vary inversely as its nasal index; tribes with the highest index having the lowest social rank, and *vice versâ*. In the brachycephalic group social status appears to vary with the cephalic index. An attempt was made to deduce a theory of the probable origin of caste, and also to account for the custom of exogamy by the operation of the law of natural selection.

Prof. A. C. Haddon read a paper on some former customs and beliefs of the Torres Straits islanders. The natives of Torres Straits are divided into two distinct tribes—the eastern tribe, which inhabits Uga, Erub, and the Murray Islands; and the western tribe, which occupies all the remaining islands. The islanders were divided into clans, each clan having some animal for its totem, such as the dugong, turtle, dog, cassowary, snake, shark, &c. The women used to have a representation of their totem cut on the small of the back. In the western tribe the lads on entering into manhood underwent a month's isolation in the bush. In the eastern tribe two elaborate ceremonies attended the initiation of the lads, but the discipline does not appear to have been so severe as in the other tribe. It was the custom in the western tribe for the women to ask the men in marriage. On the other hand, in the eastern tribe the men proposed to the women, and the women had to undergo a period of partial seclusion previous to marriage. The eating of food together was a feature in marriage. Belief in sorcery was universal, and all sickness and death were attributed to the charms of the medicine-man. There were also rain and wind makers.

Some observations on the natural colour of the skin in certain Oriental races, by Dr. J. Beddoe, F.R.S., was read. The author made numerous observations of this kind in the course of a voyage round the world. In most cases he found the colour of the clothed and protected body much lighter than is generally supposed. The capacity to tan, or become darker by exposure, varies much: thus the Melanesians are naturally lighter than the Australians, but they burn much blacker.

The following papers were contributed by Dr. R. W. Felkin: the normal temperature of the Soudanese, Negroes, and Europeans in Tropical Africa; and the differences of sensibility between Europeans and Negroes, and the effect of education in increasing the sensibility of Negroes. Some anthropological notes collected by Mr. Edward Beardmore at Mowat, Daudai, New Guinea, were also read.

On Tuesday, September 17, Dr. Fridtjof Nansen read a paper on the Esquimaux. He said they were a race by themselves, and he did not think anthropologists agreed yet as to their real origin. He thought that tradition showed the Esquimaux really came from America. The Esquimaux of Greenland were now divided into two classes—those on the west coast who had been civilized by the Danes, and those on the east coast who were uncivilized. Esquimaux were seen in the north in 1823. The eastern Esquimaux had warmer clothes than the western ones. The young girls wore their hair loose, but afterwards they put it up in a knot at the top of the head, as a sign that they were ready for marriage. The Esquimaux, as a rule, lived in small tribes, and as many as ten families often lived in one hut. The Esquimaux had no written laws, but they had unwritten laws, which were kept strictly. The head of the house and the chief of the tribe was the best catcher of seals. As to property, they did not really know that word. No man had anything for himself, and any seals caught were divided between the families. They did not steal from each other, but they liked to steal from Europeans. Murder was not uncommon amongst the Esquimaux, and the punishment was really nothing at all. The men married as soon as they could catch sufficient seals to provide for a wife. Near relations, such as cousins, never married. On the east coast some men had two wives, the reason being that one wife could not prepare all the seals they caught. The children were not punished. Weak and deformed children, and those who lost their mothers, were as a rule thrown outside the house or into the sea. Old people, who were ill, were often thrown into the sea. He thought the time would come when the Esquimaux would be extinct.

The Rev. G. Rome Hall read a paper on Northumberland in prehistoric times. On the east coast of England no trace of the Cave-men had as yet been found further north than Norfolk.

We came, after an immense and unknown lapse of time, to the Neolithic period, when the earliest inhabitants of Northumberland, who were, so far as can be ascertained, cognate with the Basques and Lapps, crossed the Tyne in small family or tribal bands. Though probably never numerous, their polished weapons and implements had been frequently found. Considerable hoards of bronze had been found near Alnwick, Rothbury, and Wallington. Beads of gold were discovered in a barrow at Four Laws, or Chesterhope. Near Bellingham, in North Tynedale, a gold armlet was found. Burial by inhumation was customary in the later Stone Age, and cremation followed. Interments were sometimes in split oak coffins, found at Featherstone, but usually in stone-lined graves, the body being doubled up as in the posture of sleep, sometimes with an iron food-vessel placed near the head. The author explained the migrations of the people in early times. To the Iron period we owed the introduction of the greater part of the names of local mountains, hills, rivers, and streams, as the Tyne from "don" or "tan," the water. The bronze-using invaders may have landed in England about B.C. 1000, and the Iron Age in Northumberland might have begun about B.C. 500 or 400. Modern Northumbrians, he concluded by remarking, might perchance owe more than they thought to the combination of racial characteristics resulting from the continuity of life proceeding from even prehistoric times down to the present day.

Sir William Turner read a paper on implements of stags' horn associated with whales' skeletons found in the Carse lands of Stirling. He showed that skeletons of whales had been found, together with implements of stags' horn. The discovery of these horn implements showed that when the fertile land now forming the Carse of Stirling was submerged below the sea-level, the surrounding high lands were inhabited by a hardy Caledonian race, who manufactured useful tools and weapons from the antlers of the red deer. It was probable that the whales had been stranded during the ebb of the tide, and that the people had descended from the adjacent heights, and, with the aid of their chisels of horn, had spoiled the carcass of its load of flesh and blubber. There was nothing in the shape of those implements to lead anyone to suppose that they could be used in the chase of the whale. The period of this people was probably covered by that termed the Neolithic, the termination of which was stated to be from 5000 to 7000 years ago.

Mr. Bernard Hollander read a communication on the relations between brain-functions and human character, with the view of showing the possibility of a scientific phrenology.

The following papers were also read:—Prof. G. J. Romanes, F.R.S., on the origin of human faculty; Prof. Frazer, on a new method of illustrating the topographical anatomy of the brain; Mr. George Weddell, notes on classification in sociology; Mr. S. B. J. Skertchly, on fire-making in North Borneo, and on some Borneo traps; Mr. James Macdonald, on manners, customs, and superstitions of South African tribes.

THE MAORIS.

An unusually lengthy Report from the Registrar-General of New Zealand on the condition of that colony, which has lately been laid before Parliament, contains some interesting information respecting the present condition of the Maoris. Mr. Brown says that, according to the traditions of the Maoris, their ancestors first arrived in New Zealand from an island in the Pacific Ocean, to which the name of Hawaiki is given. Since that event it appears, from genealogical sticks kept by the *tohungas*, or priests, that about 20 generations of the race have lived. The number of the Maori race at the time of the first foundation of the colony, in 1840, was estimated at about 80,000. Twenty years previously the number had been estimated at 100,000. In 1857 an enumeration of the race was made, from which it appeared that the number of males was then about 31,667, and that of the females about 24,303; and of those whose sex was not stated, 79; a total of 56,049. Subsequent attempts at enumeration have been made; but, owing to the objections felt by natives to stating their numbers, and to the difficulties experienced in obtaining information in those parts to which the European was not allowed free access, with not wholly satisfactory results. The latest, and probably most accurate, of these enumerations, was made in 1886. This gave the number of males as 22,840, and the females as 19,129; a total of 41,969.

That there has been a serious decrease in the numbers of the race of late years is the general opinion of all competent to judge, and a consideration of the numbers of each sex, and the proportion living at each age-period, leads to the conclusion that in all probability the decrease is still progressive. In 1886 the proportion of females was 83·75 to every 100 males. In the European portion of the population the proportion was 85·28 females to 100 males. The proportions are not relatively comparable, as the excess of European males over females is caused by immigration; but there is no external cause to account for the Maori males being more numerous than the females. In the European portion of the population, under 20 years of age, the proportion was 100 males to 99 females; in the Maori population under 20, the proportion was 100 males to 87 females. The males under 15 years of age were in the proportion of 31·82 to every 100 of the male population, and the similar proportion among the females was 33·59; these being less than the proportions in 1881—an evidence of a low birth-rate, or high juvenile mortality, leading to a racial decrease.

On comparing the proportions living at each quinquennium under 20, and each decennium above that period, with the corresponding proportions in the population of England, and that of the New Zealand European, it is found that at all ages under 20 the proportions among the Maoris are far less than among the other two populations, and at each age-period above 40 the Maori proportions are far higher. It is, of course, a fair inference that the causes of these larger proportions at the higher age-periods are two-fold—namely, a low birth-rate, and a high death-rate among the younger members of the community. This is borne out by the much smaller proportions of young children to those in either the English or New Zealand European communities. The smaller proportion of females (83·75) to males (100) also shows a greater mortality among the adult females than among the males, as 42·29 per cent. of the females living were under 20 years of age, but only 39·70 per cent. of the males were under 20. The manifest decrease in the numbers of the race is much to be regretted, for the Maoris show great aptitude for civilization, and they possess fine characteristics, both mental and physical, and rapidly adopt the manners and customs of their civilized neighbours. In mental qualifications they can hardly be deemed as naturally an inferior race, and the native members of both the Legislative Council and the House of Representatives take a dignified, active, and intelligent part in the debates, especially in those having any reference to Maori interests. The Maoris contribute largely to the taxation of the country through the Customs duties; and, having regard to the relations now subsisting between the races, they may be regarded as constituting an important element of strength in the population of the colony.

On the subject of the education of the natives, Mr. Brown says the number of native village schools at the end of 1887, either supported or subsidized by the Government, was seventy-nine, an increase of eight on the number in 1886. In addition, there were two more subsidized private schools for the education of Maori children only, and seven boarding-schools for native children, the cost of whose maintenance was paid either by Government or out of endowments. The number of Maori children attending school at the end of 1887 was 2812, viz. 1612 males and 1200 females. These included children of mixed European and Maori blood, who live as members of native tribes. The following is a statement of the number of Maori children who were attending schools in 1886 and 1887:—

	1886.	1887.
At public European schools	475	343
At native village schools	1910	2215
At subsidized or endowed boarding-schools	162	156
At private European or native schools	100	98

There was thus an increase of 165 on the number of native children who were being educated in 1887. There was a decrease of 132 in the number attending European public schools, but an increase of 305 on the number attending the native village schools.

The information supplied respecting the age of the Maoris at the census of 1881 was very incomplete, and therefore only a merely approximate estimate can be given as to the numbers living at the usual school ages, 5 to 15. Out of a Maori population of 22,840 males and 19,129 females, the ages of 21,724 males and 17,936 females were given as either under or over 15 years. The proportion of those under 15, if applied to the whole of the population, would give 7226 males, and 6420 females under 15 years of age. If it be assumed that the numbers living under 5 years of age bear the same proportion to the whole number under 15 years of age as in the European portion of the population, the above numbers would give 4596 Maori males and 4082 Maori females between 5 and 15 years of age. As all the children attending the private and public schools may be fairly taken at over 5 and under 15 years of age, and the ages of those attending native schools are ascertainable, it may be roughly stated that nearly 32 per cent. of the Maori boys and nearly 27 per cent. of the Maori girls between 5 and 15 years of age attend schools.

SCIENTIFIC SERIALS.

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti, vol. xxii. fasc. xv.-xvi.—It appears from experiments here described by Signor Sormani that the Bacillus and spores of tetanus may be drawn into the respiratory passages by inhalation, or even injected into the bronchial tubes, without producing tetanus. The Bacillus is probably anaërobic, unable to develop in presence of oxygen. The tetanus called *rheumatic* is thought to be of traumatic origin really, the wound being slight, and but little of the virus introduced. Tetanus is most common in Northern Italy; its maximum being in Lombardy and Emilia, where people frequently work, in the hot season, with bare feet. They are attacked in the proportion of 100 males to 30 females. The mortality in hospitals is about 44 per cent of those attacked.—We note two medical papers: on recent innovations in treatment of free inguinal hernia (Signor Scorenzio), and on fibroma of the breast (Signor Sangalli).—An inquiry into the nature and uses of the *stufe* and warm baths of the middle and later ages is summarized by the author, Signor Corradi.—Signor Maggi writes on the principles of the theory of potential functions, and there are continuations of mathematical papers by Signors Oschieri and Giulio.

Bulletin de l'Académie Royale des Sciences de Belgique, No. 8, 1889.—M. Massart here seeks to account for the penetration of spermatozoïds into the egg of the frog by the resultant attraction of the gelatinous mass round the egg, which, absorbing water, presents a gradually increasing density inwards. If a piece of the episperm of linseed or quince be put in water containing spermatozoïds, the mucilaginous matter round it swells similarly, and, during the twenty minutes this continues, the spermatozoïds are attracted, and make their way to the centre. When the absorption ceases, they stop too. The gelatinous covering of the frog's egg, separated from the latter, in water, affects them similarly. M. Massart holds that sensibility to contact is the explanation of the phenomena (not mechanical attraction, nor a sense of the direction of the current).—M. de Heen describes a simple new apparatus for measuring the heat conductivity of some homologous organic liquids, and shows that, in a given series, the conductivity diminishes with increasing molecular weight; but the square of $\frac{1}{c}$ varies generally less rapidly than the weight. He also discusses the dilatability of liquids in relation to molecular movements.—M. Henry studies the volatility of normal cyanic ethers, and of poly-oxygenated carbon compounds; finding the simultaneous presence of oxygen and nitrogen, or the accumulation of oxygen, at one point in the molecules, a powerful cause of it. He has also a short paper on monohaloid ethers of ethylenic glycol.—M. Dewalque supplies some phenological figures for Liége, Spa, &c. A valuable paper on the svastika appears in the section *des lettres*.

SOCIETIES AND ACADEMIES.

LONDON.

Entomological Society, October 2.—The Right Hon. Lord Walsingham, F.R.S., President, in the chair.—Mr. F. P. Pascoe exhibited a number of species of Coleoptera, Lepidoptera, Hymenoptera, Neuroptera, Hemiptera, Orthoptera, and Diptera, collected by himself during the past summer at Brindisi, and in Greece and the Ionian Islands.—Mr. J. W. Douglas sent for exhibition specimens of *Lygus viscicola*, Puton, a species new to Britain, taken at Hereford, in September last, by Dr. T. A. Chapman.—Mr. R. McLachlan, F.R.S., exhibited nearly 100 specimens of Trichoptera recently collected in Iceland by Dr. P. B. Mason. Only six species were represented, and of these five had been previously recorded from the island. Mr. McLachlan remarked on the great amount of variation existing in some of the specimens.—Mr. E. B. Poulton, F.R.S., exhibited a mounted specimen of the yellow powder from the cocoon of *Clisiocampa neustria* under a power magnifying 188 diameters. The powder was thus seen to consist of crystals so minute that the form could only just be made out under this power; it was present in a crystalline form in the Malpighian tubules, and discharged from the anus of the larva. A discussion ensued as to the functions of the Malpighian tubes, in which Mr. Stainton, F.R.S., Lord Walsingham, Dr. P. B. Mason, Mr. McLachlan, and Dr. Sharp took part.—Mr. Poulton also exhibited some photographs of the living larvæ of *Hemerophila abruptaria*, showing different depths of colour which had been induced by experiment; the larvæ had been rendered very light in colour by being surrounded by green leaves and stems only, whereas they had become extremely dark when numbers of dark twigs were intermingled with the leaves of the food-plant. Mr. F. Merrifield said that Dr. Chapman had recently obtained similar results from experiments made with the larvæ of *Ennomos alniaria*.—The Rev. Dr. Walker exhibited, and read notes on, a number of Coleoptera, Neuroptera, Hymenoptera, and Diptera, which formed the second instalment of the collection which he had recently made in Iceland.—Mr. R. South exhibited a specimen of *Luperina nickerlii*, Freyer, caught in Lancashire last August. He also exhibited, and read notes on, a long series of *Boarmia repandata*, bred from larvæ collected in North Devon. Mr. Poulton, Mr. Merrifield, and Lord Walsingham took part in the discussion which ensued.—Mr. J. J. Walker, R.N., exhibited a collection of Coleoptera made during the past summer in Cobham Park, Kent. Thirty-three species were represented, amongst which were the following, viz. *Eros minutus*, *Philonthus fuscus*, *Homalota hepatica*, *Abræus granulum*, *Anisotoma grandis*, *Agaricophagus cephalotes*, *Thalycra sericea*, *Cryptophagus ruficornis*, *Platytarsus setulosus*, &c.—Herr Jacoby exhibited a curious Phytophagous beetle found by Mr. J. H. Leech in the Corea. He stated that he was unable to determine the species, as was also Mr. J. S. Baly, to whom he had submitted the specimen.—Mr. R. Adkin exhibited specimens of *Retina resinella*, received by him from Forres. Lord Walsingham remarked that he had never seen the species in Scotland, but that it was not uncommon in Germany.—Mr. W. Dannatt exhibited a male specimen of *Papilio antimachus*, Drury, received from Lukolela, a station about 500 miles from the mouth of the Congo. He stated that the species, although very rare, had a wide range, as three other specimens of it had been received from the Stanley Falls, which were more than 800 miles further up the Congo.—Lord Walsingham exhibited specimens of the larva and imago of *Cidaria reticulata*, collected in the Lake District, and sent to him by Mr. Hodgkinson.—Mr. J. Jenner-Weir exhibited fore-wings of the males of *Argynnis paphia*, *A. adippe*, and *A. atlantis*, denuded of the scales, in order to show that there was no dilatation or thickening of the median nervules and submedian nervure in that sex of these species; but that the apparent dilatation was produced by a dense mass of scales crowded together on each side of the nervules. He also read a short paper on the subject entitled "Notes on the Nervules of the Fore-Wings in the Males of *Argynnis paphia* and other Species of the Genus." Mr. Jenner-Weir said he was supported in his views by the opinions of Mr. S. H. Scudder, Dr. Staudinger, and Dr. Schatz.

SYDNEY.

Linnean Society of New South Wales, July 31.—The following papers were read:—Description of a new species of Iodis, with remarks on *Pielus imperialis*, Olliff, by Thomas P. Lucas. For the new species of Iodis—of which three specimens were recently captured in Brisbane by Mr. Illidge—the name of *P. illidgei* is proposed. The second part of the paper consists of critical remarks on *P. imperialis*, Olliff, which the author states is identical with *P. hyalinatus*, Schäffer.—The examination of kinos as an aid in the diagnosis of Eucalypts; Part 1, the Ruby Group, by J. H. Maiden. The author refers to a previous paper, in which he shows that Eucalyptus kinos may readily be grouped into three great classes, according to their behaviour with water and with spirit. Briefly, he divides them into (1) the Ruby Group, which consists of ruby-coloured kinos, the members of which are soluble either in cold water or in cold spirit. (2) The Gummy Group, whose members are soluble in cold water, but very imperfectly in spirit, owing to the gum they contain. (3) The Turbid Group, whose members are soluble in hot water or in hot alcohol, but the solutions become turbid on cooling, owing to the presence of catechin. He then deals with the first group, and shows that, with one anthereally doubtful species, the members are identical with the group Renantheræ of Bentham and Müller's anthereal classification. He shows how the examination of kinos is a valuable aid or supplement in the diagnosis of Eucalypts, and concludes this part with an account of all the ruby kinos at present known to science.—On Rhopalocera from Mount Kosciusko, New South Wales, by A. Sidney Olliff. In this short paper some sixteen species are recorded from specimens obtained by Mr. R. Helms, a most painstaking and energetic collector, who recently made an excursion, chiefly in the interests of entomology, on behalf of the Australian Museum. The collection contains both the species described from the mountain by Mr. Meyrick, as well as a new Xenica, proposed to be called *X. correæ*.—Note on the fructification of *Phlebopteris alethopteroides*, Etheridge, fil., from the Lower Mesozoic Beds of Queensland, by R. Etheridge, Jun. From the examination of additional material the author has been able to determine an arrangement of the sori similar to that in *P. polypodioides*, Brongn., and other known species of the genus.—Note on the bibliography of Lord Howe Island, by R. Etheridge, Jun. This paper is supplementary to a recently-published work ("Lord Howe Island: its Zoology, Geology, &c.," *Mem. Austr. Mus.*, 1889, No. 2), and gives a digest of certain valuable reports by Dr. Foulis, Mr. White, Captain Denham, R.N., and Dr. J. Dennis MacDonald, contained in the "Votes and Proceedings of the Legislative Council of New South Wales for 1853," and with which, when contributing to the above-mentioned work, the author had been unable to meet

PARIS.

Academy of Sciences, October 14.—M. Des Cloizeaux, President, in the chair. — Presentation of vol. iv. of the "Collection of Memoirs relating to Physics," published by the French Physical Society, by M. C. Wolf. This volume is devoted to the pendulum; and contains memoirs by La Condamine, Borda, Cassini, Prony, Kater, and Bessel. M. Wolf supplies a bibliography and chronology of works on the pendulum from Galileo's time to 1885; also an historical introduction. The fifth volume will deal with the same subject.—Reciprocal displacements between the halogen elements and oxygen; hydrobromic and hydriodic acids, by M. Berthelot. A *dilute* solution of iodide of potassium remains an indefinite time colourless in presence of oxygen; but it is otherwise with a *saturated* solution, owing to the formation of a small amount of tri-iodide. Dilution of the yellow liquor with fifty times its volume of water (or more) removes the colour almost entirely; dissociation of the tri-iodide allowing the potash to react fully with the iodine.—On transformism in pathogenic microbiology; limits, conditions, and consequences, of the variability of the *Bacillus anthracis*; researches on ascendant or reconstituant variability, by M. A. Chauveau. The natural Bacillus, with its virulence quite removed by compressed oxygen, may be revivified by degrees, thus: it is cultivated in *bouillon*, to which fresh blood of, *e.g.*, a guinea-pig is added, and in very rarefied air; it then becomes fatal to mice, guinea-pigs, rabbits, &c., and is vaccinal to small ruminants, but does not kill them. Cultivation of this Bacillus in *bouillon* to which sheep's blood is added renders it fatal to small ruminants, and probably vaccinal to the ox.—New relation between sugars and furfuric compounds; constitution of methylfurfurol and of isodulcite, by M. Maquenne. Distilling isodulcite ($C_6H_{12}O_5$) with dilute sulphuric acid, he got some pure methylfurfurol ($C_6H_6O_2$) identical with that obtained from Fucus; and he infers the presence of isodulcite in tissues of marine plants. Its relations to arabinose suggest that it may be much more widely diffused than has been supposed.—On the physical properties of the free superficial layer of a liquid, and of the layer of contact of a liquid and a solid, by M. Van der Mensbrugghe.—On doubly harmonic linear elements, by M. L. Raffy.—On the area of certain ellipsoidal zones, by M. G. Humbert.—On the fermentation of raffinose, in presence of different species of beer-yeast, by M. D. Loiseau. A claim of priority.—Observations on the communication made by M. Ch. E. Guignet, at the meeting of September 30 last, by MM. C. Vincent and Delachanal. The addition of ammoniacal sulphate of copper to the juice of sorbs precipitates sorbite itself, so the production of this precipitate does not prove the presence of mannite nor its separation from sorbite.—On the optical analysis of oils and of butter, by MM. E. H. Amagat and Ferdinand Jean. They describe a method based on variation of the index of refraction of various oils, and of the melted fatty matter of butter, due to the presence of adulterating substances.—On air contained in the soil, by M. Th. Schlœsing, *fils*. He has improved on the method adopted by MM. Boussingault and Léwy thirty years ago; he forces into the ground a steel tube with conical point, the opening of which is temporarily closed by wire. The upper end is connected by means of a capillary tube with a bulb, from which mercury is withdrawn on lowering a small connected reservoir; thus the air of the soil is drawn in. He finds abundant gaseous oxygen in the soil, and much variability at different times; details are promised.—On a musculo-cutaneous strip, in form of a flap, applied to the restoration of eyelids, by M. Léon Tripier. The strip is dissected out from one eyelid and transferred to the other side.—On the exploration and the formation of *avens*, by MM. E. A. Martel and G. Gaupillat. These *avens* are natural, open, deep pits, found in numbers on calcareous plateaus. The authors hold that four factors participate in their formation: (1) previous dislocations of the ground; (2) surface waters (erosion); (3) interior waters (erosion, hydrostatic pressure, falling in); (4) chemical phenomena. Frequently only three or two of these factors have been in operation. It is only accidentally that the *avens* communicate with subterranean rivers.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Chief Ancient Philosophies—Aristotelianism: Rev. I. G. Smith and Rev. W. Grundy (S.P.C.K.)—Toilers in the Sea; M. C. Cooke (S.P.C.K.).—Federal Government in Canada: J. G. Bourinot (Baltimore).—Elementary Manual of Magnetism and Electricity; Part 1, Magnetism: Prof. Jamieson (Griffin).—Index of the Genera and Species of Mollusca in the Hand-list of the Indian Museum, Calcutta, Parts 1 and 2 (Calcutta).—Journal of the Chemical Society, October (Gurney and Jackson).—Journal of Anatomy and Physiology, October (Williams and Norgate).—Morphologisches Jahrbuch, 15 Band, 2 Heft (Leipzig).—Journal of the Royal Microscopical Society, August (Williams and Norgate).—Key to Lock's Arithmetic for Beginners: Rev. R. G. Watson (Macmillan).—A General Formula for the Uniform Flow of Water in Rivers and other Channels: E. Ganguillet and W. R. Kutter; translated (Macmillan).—Scientific Papers of Asa Gray, 3 vols., selected by C. S. Sargent (Macmillan).—Hand-book of the Bromeliaceæ: J. G. Baker (Bell).—Ker Kompass an Bord; ein Handbuch für Führer von Eisernen Schiffen (Hamburg, Friederichsen).—A Bibliography of Geodesy; Appendix No. 16, Report for 1887 (Washington).—Calendar of the University College of Wales, Aberystwyth, 1889–90 (Manchester, Cornish).—Les Industries des Animaux: F. Houssay (Paris, J. B. Baillière).—Glasgow and West of Scotland Technical College Calendar for the Year 1889-90 (Glasgow, Anderson).—The Engineer's Sketch-book: F. W. Barber (Spon).—Proceedings and Transactions of the Royal Society of Canada for the Year 1888, vol. vi. (Montreal, Dawson).—Iris; Studies in Colour and Talks about Flowers: F. Delitzsch, translated by Rev. A. Cusin (T. and T. Clark, Edinburgh).—Steam: W. Ripper (Longmans).—The Tornadoes and Hailstorms of April and May 1888 in the Doab and Rohilkhand: S. A. Hill (Calcutta).—Journal of the Royal Statistical Society September (Stanford).—Journal of the Scottish Meteorological Society, 3rd series, No. 6 (Blackwood).—Journal of Morphology, vol. iii. No. 1 (Boston, Ginn).

CONTENTS.

THURSDAY, OCTOBER 31, 1889.

"OXFORD AND ITS PROFESSORS."

A TRENCHANT article in the last number of the *Edinburgh Review* arraigns and passes judgment on the University of "Oxford and its Professors." The evidence clearly establishes the facts that the lectures of the great majority of the Professors are but poorly attended, and that, in spite of the efforts of two Commissions, the relations between the University and the Colleges, regarded as allied educational institutions, are not satisfactory. On the causes of this unhappy state of things we do not desire to dwell, but, although agreeing on many points with the author of the article, we must protest strongly against one of the remedies which he suggests.

"Why," he asks, "should not the Universities recognize the principle of division of labour? . . . Why, for instance, should not Cambridge provide thoroughly for the teaching of natural science; and Oxford as thoroughly for that of theology? . . Let the Universities abandon individualism and accept individuality. Let one group of allied subjects be studied in Oxford; another at Cambridge."

It is true that the Reviewer thinks that "a University ought to provide a liberal education, competent to form the basis of that technical training which is special to every trade and profession," but he contends that "beyond this general course, the minutely differentiated special studies into which human knowledge is now necessarily distributed must be recognized and ordered."

We are convinced that an attempt of this sort to confine the special studies of each University to particular lines would do infinite harm. It is not only the students, but the teachers, who are benefited by mingling with others who are their intellectual equals, but whose intellectual activities are put forth in other directions.

It is easy to say that London is within an hour and a half of Oxford or Cambridge, and that London society will widen views which might otherwise contract, and prune down eccentricities which might become serious defects. It is not, however, true, and it is not likely to become true, that the average teacher in a University has society of this sort open to him in early life. More and more frequently—to their honour be it said—lads who begin in the elementary school fight their way to University distinction. Others who start from a position of greater social advantage move "at home" in circles in which literary or scientific ability is rare, and in which they are much more likely to be spoiled by indiscriminate admiration than restrained by judicious criticism.

For a large number of young Fellows of Colleges, the High Table and the Common Room furnish, during the most impressionable years of life, the highest intellectual and social society to which they can attain; and many of those who travel beyond these limits extend the bounds of their acquaintance chiefly among those who are interested in the same special studies as themselves.

It would therefore work terrible mischief if the gulf between specialists were widened by driving them into different Universities. Oxford, we may be sure, would fight to the death against being converted into a mere school of theology. It is said that one of its Colleges some years ago refused an endowment of many thousands which was fettered with the condition that it should benefit only members of a particular Church; and in this temper the suggestions of the Reviewer would be met.

Surely no man who wished well either to the Universities, or to religion, or to science, would desire to see future curates relegated in a body to the Isis, and would-be demonstrators to the Cam; or would mould a Common Room on the pattern of a Clergy House, while a Combination Room was fashioned into a likeness of the Secretarium of the British Association.

Nor do we adopt this view merely on the ground that it is well that students of other branches of knowledge should be leavened by mingling with those who cultivate science. No critic is so unsparing, so useful, and so inoffensive as an intimate friend, and scientific men need criticism as much as others. A hint that, however valuable the scientific results of a treatise may be, they are announced in execrable English, can be conveyed by a college chum better than by anybody else. The Huxley or Tyndall of the future will sometimes be none the worse for the reminder that his predecessors, if they popularized science, did not vulgarize it, and that scientific papers which possibly contain useful additions to knowledge are certainly literature, and, as such, must be tried by the ordinary canons. In short, it is on behalf of the younger scientific men that we claim that those among them who study in our Universities shall not be deprived of the advantage of intimate relations with fellow-students of their own standing, whose aims in life, and modes of thought, are other than theirs.

The argument from economy is sufficiently met by the above considerations, but it is absurd to contend that there is not room for two great schools of science in the Universities, if proper means are taken to fill them.

In every provincial town, Colleges are springing up which are far better equipped than were the Universities themselves some twenty years ago, and the number of their students steadily increases. In Cambridge, the scientific lecture-rooms and laboratories are full to overflowing; and we cannot but believe that, if Oxford is less successful, the comparative failure is due either to temporary causes, or to some defect of organization which could be discovered and remedied.

According to the Reviewer, the relations between the Professoriate and the Colleges are not harmonious, and, if this be so, natural science is probably more injuriously affected than any other branch of study. Centralization, harmful in many cases, is essential in the teaching of a subject which at present attracts a small number of very advanced students, while the machinery for the instruction of elementary students must necessarily be expensive. That it can be attained without trenching on the legitimate privileges of the Colleges is proved by the fact that, in spite of the existence of the Collegiate system, Cambridge has become a great school of science.

SUBJECTS OF SOCIAL WELFARE.

Subjects of Social Welfare. By the Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., Ph.D., F.R.S. (London: Cassell, 1889.)

IN this volume Sir Lyon Playfair has collected a series of his essays, speeches, and lectures, composed or delivered during the last half-century. The volume is divided into three parts, the first dealing with questions relating to public health, the second with various economic problems, and the third (of course) with educational topics. Though most of the essays are more or less scientific in character and mode of treatment, only one is purely scientific, viz. that on "Sleep and some of its Concomitant Phenomena," which contains, with a few alterations, the substance of a lecture delivered before the Royal Institution in 1846.

The whole forms a volume which, if it will add nothing to the great reputation of the author, is eminently readable, and exhibits his usual power of apt illustration and dexterous handling of masses of facts. It is not, indeed, a book which many will read from cover to cover, for, as is natural when we consider the conditions under which its contents were originally produced, there is a considerable amount of repetition both in the subjects and in the mode of treatment. But readers in search of trenchant arguments and pointed illustrations on such debated questions as vivisection and vaccination will find both in the lucid and pithy discourses devoted to these subjects by Sir Lyon Playfair; and there is a great variety of interesting economic facts drawn both from Europe and America in the second part of the volume, which deals with industrial wealth. We cannot, however, candidly say that we regard the second section of the book as satisfactory. Much of it was originally intented to serve a definite and temporary purpose—to confute an adversary or to reassure wavering adherents of Free Trade—and for such a purpose it was well adapted. It came under the head of what an eminent politician has called the literature which to-day is and to-morrow is (or at least should be) cast into the oven, and its preservation will, we fear, serve no useful end. When, for example, Sir Lyon Playfair declares that, "so far as regards politics, ethics, sculpture, painting, and architecture, the world has advanced little beyond, if it has reached, the position attained by Greece and Rome. These, though they grace, do not now form the foundation of a nation's prosperity. That is formed from the applications of science to industry," he is expressing an opinion which may have been the passing sentiment of a moment, but which he will hardly care to have permanently associated with his name.

One of the weakest of the papers is that on bimetallism. Sir Lyon Playfair does not appear to realize the point of view of the bimetallist economists, who, however unpractical they may be, are not wanting in theoretic knowledge and power of analysis, and who are certainly not in such a state of fog as to the cause and regulator of the values of the precious metals as their critic seems to suppose. Such men as President Walker, whose exposition of the question is not lacking in clearness, certainly never subscribed to the opinion gratuitously thrust upon bimetallists by Sir Lyon Playfair, that the value of gold and silver can be fixed by statute *independently* of the state of demand and supply. But a very brief examination of the subject will make it clear that the establishment by a considerable number of nations of a legal ratio between the values of gold and silver would be a most powerful factor in altering the conditions of demand, by making the two metals alternative for the purpose for which they are most largely used. This automatic action of the "bimetallic bond" would be comparatively insignificant in the case of a single nation surrounded by monometallic countries, because the neighbouring countries would offer such a wide area for the overflow of the dearer metal, which might thus all drain away before matters could readjust themselves; but it would become theoretically very powerful if four or five of the great nations could unite for the establishment of the double currency. The real objection to such a policy arises from the practical difficulty of forming a strong international monetary union, and the physical fact that silver is much heavier and more inconvenient to carry than the equivalent value in gold. These difficulties are very real in practice, but it is useless to suppose that the bimetallic position is turned by an appeal to the action of the Chinese Emperor Wang-Mang, who is said to have proclaimed a legal ratio of value between (*sic*) five shells—in which attempt he very naturally failed.

It is time also that economic writers gave up the vague references to supply and demand as the cause of all things; as though supply and demand were ultimate facts incapable of being further analyzed and explained. "These *laws*," says Sir Lyon Playfair, "are all-powerful, and no statute *law* of one nation or of ten combined nations can prevail against them." (The italics are ours.) Now what is this but a revival of the old confusion between the two meanings of the word "law," which once led a writer in a leading Review to question the use of economic laws unless enforced by the police? In other essays Sir Lyon Playfair declares (with truth) that Protection raises prices and lowers wages. Is not this a case of a statute law "prevailing against," or (as we should put it) modifying, the conditions of supply and demand?

In the same lecture on bimetallism Sir Lyon Playfair told the National Liberal Club that "gold might be stationary in quantity *and value*, while the prices of commodities might fall from causes having no relation to it, and then its appreciation or power of increased purchase would be a contemporaneous fact but not a cause of the depreciation." How can "value" be stationary while "purchasing power" rises? The meaning of the passage is not obscure; but the looseness of phraseology is deplorable in a science in which strictness in the use of terms is so essential. Would Sir Lyon Playfair say that a schoolboy had not gone up in class because it was the fault of his companions that they had gone down?

A far more thoughtful essay is that on the displacement of labour by modern inventions, in spite of the use of such loose phrases as "labour has suffered much less than capital," and the old confusion between changes in the *rate* of profit on capital and the (totally distinct) *amount* of profit reaped by the capitalist. Sir Lyon Playfair was personally acquainted with the three great discoverers, Oersted, Faraday, and Wheatstone, who have revolutionized commerce by their electrical researches; and he views the changes which are taking place in modern industrial conditions from a large and philosophic point of view, seeing in them the inevitable dislocations and friction resulting from a slow and difficult readjustment of industry consequent on new discoveries. To take one case. The discovery of the mode of making madder from coal tar has reduced the importation of natural madder into this country from 22,000,000 pounds in 1872 to 2,000,000 in 1887. What has become of the former madder-growers? To what industry have they betaken themselves? What class of producers have they in turn displaced by so doing? Sir Lyon Playfair does not attempt to follow out such questions as these, bnt his essay suggests them, and it would be well if they received more attention than has hitherto been usual among economists.

There are several articles dealing with various phases of industrial competition. They all expose the fallacies of fair trade, and all lead up to a demand for technical education. Sir Lyon Playfair has here used to advantage the facts collected in his recent visit to America; but when so many sound arguments lay ready to his hand, where was the necessity of resorting to the essentially unsound reasoning that Protection is conclusively shown to have lowered wages because the wages in *some* unprotected trades (carpenters, bakers, and printers) are higher than wages in *some* protected trades (cotton-spinners, weavers, tailors, and machine-makers)?

The third part of the volume deals with questions of education. Here Sir Lyon Playfair is more at home. Long before technical education became a fashionable cry, he had urged its importance upon the public, and he has lived to see in some measure the fruition of his endeavours, of which the speeches and lectures collected in the volume before us form no unimportant share. The subjects treated range from primary education (on which there is a reprint of a very interesting address delivered at a very interesting time, viz. immediately after the passage of Mr. Forster's Act of 1870) to the relations of the Universities to professional education, on which, as might be expected, Sir Lyon Playfair takes a strong and decided line. "Each profession," he says, "has its own foundation of liberal culture. At present the Universities try to build all professions on one uniform foundation, though this is as foolish as it would be to build a palace, a gaol, or an infirmary on a single ground plan common to all. The professions have indicated by their special literary examinations what their several foundations should be; and if the Universities know how to extend their obligations to modern society, they should have little difficulty in again assuring their original purpose of affording a liberal culture to the professions. The Universities would gain in strength and the professions in dignity and in efficiency." This was spoken in 1873, and the last sixteen years have seen a very marked advance on the part of the old Universities in the direction indicated by Sir Lyon Playfair, though many authorities will still disagree with his general conclusion.

An interesting address is inserted on technical education, which, though delivered in 1870, contains matter for thought at the present day, and reminds us how long the British public have taken before awaking (if indeed they can yet be said to be awake) to the importance of doing something as a nation to raise the standard of instruction in the principles of science and art applicable to industries. We could wish, indeed, that Sir Lyon Playfair, who so powerfully calls attention to the need, had given us a little more in the way of positive suggestion; there are parts, too, of the essay which may be taken to encourage the heresy that the province of the technical school is to replace the custom of apprenticeship and take the place of the workshop. We are strongly in favour of the movement for technical education, and we hailed even the Government measure lately passed, halting and inadequate as it is, as being at least a step forward in the right direction. But if it is to be used to encourage the teaching of a smattering of a large number of trades, instead of giving a thorough training in scientific and artistic principles of more widespread application, it may be that it will do more harm than good; and it is time, now that the measure has become law, for the advocates of technical education to make themselves heard with no uncertain voice upon this all important point. Meanwhile, it is no small praise to say, and we say it with truth, that there is no man living to whom the advance of public opinion on the subject of technical education in recent years is so much due as to the author of "Subjects of Social Welfare."

SERVICE CHEMISTRY.

Service Chemistry. By Vivian B. Lewes, Professor of Chemistry, Royal Naval College, Greenwich. (London: Whittingham and Co., 1889.)

IN this book Prof. Lewes treats of chemistry in its relations to the subjects which are of immediate interest and importance to our naval and military services. Although primarily intended for the officers passing through the Royal Naval College, much of the matter of the book has a direct bearing on the work of the soldier. The necessity for such a book is obvious. Of course, as Mr. Lewes is careful to point out, there is but one chemistry, and its principles and theories are the same, no matter how the science is made subservient to the wants and different callings of men. But it is manifestly absurd to suppose that our soldiers and sailors need to be taken over the whole field of chemical science in order to obtain such a knowledge of those principles as will be of use to them in their professions. No doubt, in the interests of knowledge itself no course of instruction can be too extended, but in the case of the officers of both branches of the service there is the practical difficulty of time. The scheme of instruction at our naval and military colleges is so elaborate, and the amount of time allowed for study is, comparatively speaking, so limited, that it is absolutely necessary that the teachers of chemistry in such colleges shall restrict themselves to the treatment of the relations of chemistry to the practical work of the services. Nor will the teachers have cause to complain of any lack of subject-matter for their lectures. Even if the young officer came to his work with a fuller knowledge of the elementary principles and facts of chemical science than is usually furnished to him at school, so that his teacher at college could at once proceed to treat of its technical bearings so far as these have reference to the work of the soldier and sailor, there would still be ample matter for even the most extended course of instruction that would be practically possible. Of this fact Prof. Lewes's book gives ample evidence. The general character of our public-school education, in spite of recommendations of Royal Commissions and British Association Committees, and repeated warnings of men like Huxley and Spencer that the conditions of modern civilization imperatively require a readjustment of the curriculum of our schools, is still such that the teacher has to assume an entire ignorance of even the most elementary facts of physical science. The students at the Royal Naval College are no doubt largely recruited from the public schools. Any well-devised scheme of school instruction ought, one would think, to give them such a knowledge of the rudiments of chemistry as to obviate the necessity for the teacher to spend a considerable fraction of the limited time at his disposal in discussing such matters as nomenclature and notation, formulæ and equations, the simple laws of chemical combination, effects of temperature and pressure on gases, and so on. But Prof. Lewes no doubt, as indeed his book demonstrates, finds it absolutely necessary to deal with these preliminary matters in the outset of his course. Hence the book naturally divides itself into two portions—one, and of course the most important portion, treating of the technical relations of chemistry to the work of the services; and the other treating of such of the general principles of the science as are necessary to an intelligent appreciation of these relations. The latter portion, of course, precedes the former in the actual plan of the book.

It is, however, characteristic of the eminently practical character of the book that Prof. Lewes loses no opportunity of pointing the moral by some reference to a "service" fact. Thus he has occasion to treat of the chemistry of the galvanic battery, and what he has to say about the electro-chemical behaviour of metals leads up to the question of the fouling of ships' bottoms; the possibility of strong galvanic action set up in iron ships causing the destruction of the screw shafting and rudder-posts, &c.; the effect of mooring a copper-bottomed vessel to an iron pier, &c. No officer intelligently following a course of instruction such as this can be blind to the influence which science is capable of exerting on the work of his profession. The sailor whose respect for a fluid which is so useful in navigation is so profound as to forbid him to drink of it, would doubtless have that respect intensified by the account which Prof. Lewes gives of the physical and chemical characters of water, although, possibly, the section on filters and filtering media may have only an abstract interest for him. This chapter, of course, contains nothing but what is the common property of text-books; but it is put together in such a manner as to show the bearing of the facts on the every-day life and work of the sailor. The chapters on Boiler Incrustation and on Ventilation are also capital illustrations of the way in which the service aspects of the matter are dealt with throughout the book. A short account of carbon, its oxides, and simplest hydrides, naturally leads up to a description of the manufacture of coal-gas, the nature of luminous flames, the causes of fire-damp explosions both in the mine and in the holds of vessels; whilst the chapter on fuel is of especial interest, from the manner in which the results obtained by the Commission on the Navy coal, and the reports as to the value of liquid fuels, are summarized and discussed. The methods of calculating the evaporative value of fuel from percentage composition, and the mode in which such calculations are checked by calorimetric determinations, are also described, and their precise value indicated. The subject of Explosives naturally takes up a considerable space. The mode of manufacture of service powders, cocoa powders, amide powder, &c., is fully described and illustrated, and the nature of the chemical changes on firing gunpowder, as determined by Noble and Abel, Lenck, Karolyi, Bunsen, and Schischkoff, is explained in detail. The chapters have indeed been put together with special care, and contain much that has not yet been incorporated with any other text-book, not only as to details of manufacture, composition, and mode of decomposition, but also as regards proving and keeping. This question of the effects of storing in overheated and badly ventilated magazines is extremely important, especially in regard to powders for large ordnance, and the little that is at present known on the subject is stated in the book.

Only such compounds of the metals and non-metals are dealt with as have immediate relation to service questions. In treating of the action of light upon silver salts the author gives a concise account of the more important methods of photography with special reference to dry-plate work; and the book concludes with a chapter on the chemical nature of the more generally used inorganic pigments, and on the causes of corrosion and fouling of ships' bottoms and marine boilers. This constitutes one of the most valuable sections of the work, and embodies the results of much reading and original investigation.

We congratulate Prof. Lewes on having compiled a most useful and eminently practical work. It of course makes no pretensions to be a complete manual of inorganic chemistry, but it seeks to deal in the most direct manner with those matters which are of special interest to the class of readers for which it is specially intended. It is capitally printed, and for an English text-book, unusually well illustrated; indeed, the entire "get up" of the work reflects great credit on the publishers. The book is, on the whole, well up to date, and every care has apparently been taken to verify statements of numbers and constants. The mode of decomposition of potassium chlorate given on p. 66 should, however, be amended in view of the work of Teed, and of Frankland and Dingwall; and the statement as to the action of peroxide of manganese in facilitating the breaking up of the chlorate requires alteration. It may also be pointed out, in view of the passage on p. 70, that oxygen compounds of fluorine *are* known, *e.g.* the oxyfluoride of phosphorus. Chlorine also *has* been solidified, and the statements as to the boiling and melting points of bromine and iodine given on pp. 315, 317, and 320 are conflicting. The figure on p. 379 is hardly a sufficiently accurate representation of a puddling furnace. However, these are but minor blemishes that can readily be rectified in the second edition which we trust may be speedily called for.

WATTS' DICTIONARY OF CHEMISTRY.

Watts' Dictionary of Chemistry. Revised and entirely rewritten, by M. M. Pattison Muir, Fellow of Caius College, Cambridge, and H. Foster Morley, Professor of Chemistry at Queen's College, London. Vol. II. (London: Longmans, Green, and Co., 1889.)

THE appearance of the second volume of the new edition of "Watts' Dictionary" will be welcomed, not only by chemists of every persuasion, but by all who love and work at science. This volume, reaching from

"Chloral" to "Indigo," not only gives descriptions of all important chemical elements and compounds contained between these two heads, but contains short articles on matters of general chemical interest, both of theory and of practice. The editors desire to give their work a truly international character, and we find valuable contributions, not only from eminent English specialists, but from equally competent authorities in Washington, Baltimore, and Sydney; whilst the presence of articles from the pen of a lady—Miss Ida Freund, of Newnham—indicates that scientific research and exposition are no longer to be confined to the hands and heads of the so-called stronger sex.

In turning over the eight hundred pages of this closely but clearly printed volume, one is first struck by the enormous mass of detail with which the editors have had to deal. Not what to print, but what to leave out, is the problem which all writers whose hard fate it is to have to record the present condition of chemical science have to try to solve. So enormous is the number of chemical substances which each day brings forth, so complicated are the questions of theory which their existence raises—questions which therefore vary from day to day and from month to month—that to give a clear and yet complete account of them may indeed be said to "pass the wit of man." Still, this, like other difficult problems, has to be attempted, and upon the way in which the attempt is made depends the success or failure of a work of this kind. Unless the student can gain a clear and correct idea of the present condition of the science as regards the special subject of the article upon which he seeks information, the book is worse than useless. Unless the specialist can find at least some sort of light and leading, and is supplied with references for detail to the work done by his forerunners, the "Dictionary" will be of but poor service to him. I venture, however, to think that, tried by both these standards, the verdict of the public will be that the editors have acquitted themselves well, and that this second quarter of the new chemical "Dictionary" will rank as high as the first already does, and will bear favourable comparison with the older parent volume—now, alas, with its author, numbered with those whose names have for us only an historic interest.

A dictionary merely confined to an enumeration of the names, composition, properties, and constitution of the many thousands of chemical compounds now known, like the classical work of Beilstein—however valuable, nay essential, to the student in the higher terms of the series—is not what the beginner or the general scientific reader or worker needs. He must have access to a book in which both the general and the special problems of the science are discussed with full knowledge of the position of the day. That this necessity has been understood, and carefully provided for, is seen by the list of articles furnished by special contributors, as well as by glancing at those written by the editors themselves. In that on "Chemical Classification," by Mr. Muir, we find an able statement of the case, with the modest introduction that "in the following article nothing more is attempted than to sketch the outlines of the methods by the employment of which a fairly satisfactory scheme of chemical classification may be attained," followed by the well-known definition of scientific classification given by Jevons in his "Principles of Science." The article on "Crystallization," by Mr. Harry Baker, is a model of perspicuity, and, whilst much shorter than the article on the same subject in the former edition, is sufficiently comprehensive for those who wish to gain a knowledge of the principles of this important branch.

Of all the special articles, perhaps that by Prof. J. J. Thomson, of Cambridge, on "Chemical Equilibrium," and that on "Dissociation," by Prof. Threlfall, of Sydney, are the most interesting and important. Both of these articles seem to give a new tone to ordinary chemical life; they introduce the chemist to fresh fields and pastures new. They point to the fact that the stream dividing chemistry from physics has been bridged over, not only at one point but at many, and that certain chemical phenomena which beforetime have been considered as apart and distinct can now be shown to be capable of mathematical treatment, as belonging to the domain of molecular physics.

Whilst, however, in certain directions chemistry is rapidly becoming a branch of physics, there are other chemical phenomena which ally themselves with those classed as biological, and of the most important of these the "Dictionary" gives us an example in an excellent though too short article on "Fermentation and Putrefaction," by Dr. Rideal. Prof. Ira Remsen, of Baltimore, contributes two articles, one on "Equivalency" and one on "Formulæ." In this latter he reminds us of a fact known to but few that the symbolic notation introduced by Dalton in 1808 had been preceded by an attempt, though a less satisfactory one, in the same direction by Hassengratz and Adel in 1787, though we may be sure that of this attempt the Manchester philosopher was in blissful ignorance.

Other special articles, such as those on "Combustion and Flame," by Prof. Thorpe, on "Dextrin," by Mr. O'Sullivan, on "Cinchona Bark," by Mr. David Howard, amongst many others, have only to be mentioned to show the value and interest of the volume, which (in spite of necessary shortcomings, and of occasional unavoidable errors, which some may care to seek for, though I do not) appears to me to be well worthy of the name it bears, of the house which publishes it, and of the science which it expounds, and this is saying a great deal.

H. E. ROSCOE.

OUR BOOK SHELF.

Index of Spectra. By (W. Marshall Watts, D.Sc., &c. Revised Edition. Manchester: Abel Heywood and Son, 1889.)

DR. WATTS is to be congratulated upon the completion of his great undertaking—namely, to collect all the existing measurements of laboratory spectra, and arrange them in a manner convenient for reference. Since the last edition of the book was published, seventeen years ago, spectroscopic research has made enormous progress, as a comparison with the new edition will show. This is no doubt partly due to the increased number of workers, and instrumental advances, and to a large extent to the extension of the spectroscopic field into the ultra-violet and infra-red. In the old tables the limits of the spectra were practically 394 and 670, whereas in the new ones the lines range from 204 to 770. Spectroscopy has also advanced in another direction. It was formerly believed that each substance had its own characteristic spectrum, from which there was no departure; but subsequent researches have shown that the spectrum does not entirely depend upon the substance under examination, but also upon the conditions of temperature and pressure. In the old tables, for example, only one spectrum of oxygen was recorded, but now no less than three are given. Hydrogen, again, has now two spectra recorded, and nitrogen three, including Hasselberg's important observations.

The wave-lengths given in Ångström's "Spectre Normal du Soleil," with a few small corrections, are still taken as the standards for reduction. The tables printed in the Reports of the British Association Committee form the basis of the new edition, but there are also many important additions. One new feature is the addition of a column giving oscillation frequencies, in number of waves per centimetre *in vacuo*, which will no doubt be appreciated most by investigators of the molecular origin of spectra. Tables of the spectra of various compounds, such as ammonia, alumina, and other oxides, chlorides, iodides, &c., and water, are also given. The different substances are arranged alphabetically as in the old edition, and at the head of each there are full references to books and memoirs. The introductory matter has also been considerably expanded, and now forms an excellent guide to spectroscopic scales and methods of mapping. The use of a lens to throw an image of the light source on to the slit, a method which has yielded many valuable results, is, however, unfortunately omitted. The book will be heartily welcomed by all who are engaged in spectroscopic work, and no recommendation of ours is necessary.

A Text-book on Steam and Steam-Engines. By Prof. Andrew Jamieson, M.Inst.C.E. (London: Chas. Griffin and Co., 1889.)

WE welcome with pleasure the fifth edition of this work. Few engineering text-books are intelligible to the average student. Many writers, in dealing with even the simplest engine or mechanical contrivance, completely fog the reader's understanding by the undue use of mathematics and abstruse formulæ. The volume before us is the best yet published for use in the engineering classes at our schools and colleges. Prof. Jamieson has treated the subject in a sensible and useful manner; his examples are worked out as simply as possible; and the descriptions throughout the work are those of a practical man who knows his business.

The new edition contains many extensive and important additions both to the text and illustrations. The chapter on locomotives has been considerably enlarged and improved. An express-engine built by Messrs. Dubs and Co., the eminent Glasgow locomotive builders, is taken as an example, and many well-executed scale-drawings are given as illustrations. Even with these additions the chapter does not do justice to this important branch of engineering, and Prof. Jamieson must not overlook the fact that he has many locomotive engineer apprentices attending his Glasgow classes. The few paragraphs on the compound locomotive are decidedly weak. Mr. Webb's compound locomotive "The Experiment" is excellent ancient history, no doubt; but why not describe the more recent Webb compounds, or, better still, the Worsdell and Von Borries two-cylinder compounds, now doing such good work on the North-Eastern and many foreign railways?

N. J. L.

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.*]

An Unusual Geological Sequence.

IN a late expedition to the north-west coast I have come upon evidence of a fact which was quite new to me—namely, that the well-known Cambrian red sandstones of Ross and Sutherland do not always rest upon the Archæan gneiss, but occasionally on dark blue stratified rocks with which the sandstones are perfectly conformable. For many years I have been familiar with the ordinary sequence, according to which the Cambrian or "Torridon" sandstones rest unconformably on the Archæan gneiss with nothing interposed between them. Nowhere in Sutherland, or in Loch Torridon, so far as I have observed, is there any variation in this order, and I have stood on some hills in Sutherland where the Cambrian sandstones are represented by only a few remaining cakes of conglomerate which lie bedded almost horizontally upon highly unconformable gneissic strata. I was therefore mnch surprised to see in a little creek on the eastern shore of the Island of Rāāsay, a low precipice of the red sandstone terminating in conformable beds of a rock of very dark colour, and with a texture but little crystalline. The sudden and violent change of colour at once attracted my attention, and on landing and obtaining specimens I found there could be no mistake that the Cambrian sandstones here rest upon some older rock totally different in mineral character from the Archæan gneiss, and equally different from themselves.

Pursuing this (to me) discovery, I examined the eastern face of the same island, where its precipices include fine escarpments both of the Secondary and of the older rocks. There, at one point, I found the same unusual sequence beautifully distinct. The sandstones are represented by a bed of strong conglomerate, and this bed rests conformably upon well stratified rocks of a blue, or dark blackish-blue colour, with a fracture far less crystalline than most of our Silurian slates on the mainland of Argyllshire.

Following up the same clue, I found that on the western shores of the Island of Scalpa, these blue rocks underlie in great thickness the red sandstones which form the bulk of the island, and which are exclusively seen by all who approach it from the eastern and northern sides.

I now understand that this fact has been for some time known to Dr. Geikie, and that the officers of the Survey under him have come across it with equal surprise, in certain parts of Ross-shire. But, so far as I know, it has not been published, and is not generally known.

In one specimen which I obtained on Scalpa there are obscure indications of Annelid borings, together with calcareous cavities, which are very suggestive of an organic origin.

If these rocks really belong to the Cambrian series, as this complete conformability would imply, and if they have been wholly removed in all but a few spots, before the Torridon sandstones were laid down, the fact gives one a good deal to think of both as regards the intervals of time which they represent, and as regards the agencies of change which must have been at work.

To what horizon do these blue rocks belong? The Sutherland fossils from Durness are thought to be among the very oldest Silurian forms. Below these come the great white quartzites of the same county. Below them, again, unconformably, come the Torridon sandstones, and lowest of all come these subsequent blue beds—not at all metamorphosed—less crystalline than many of the secondary rocks. Yet they must be amongst the very oldest sedimentary rocks known to us.

I may add that I found by actual experiment that in a deposit now forming here, of the same blue colour, Annelid burrows develop precisely the same ferruginous stains which I find in the Scalpa specimen before referred to. ARGYLL.

Inveraray, Argyllshire.

Mr. Galton on Natural Inheritance.

MR. GALTON'S recent ingenious book on natural inheritance suggests some remarks on the value of his method and results. In the first place, it is plain that the method of probable error, which he uses, is only applicable with any certainty to cases where a multiplicity of unknown or unanalyzed causes ("accidents," pp. 19, 55) determines some mathematically measurable quality. Eye colour, artistic faculty, and temper, to which Mr. Galton applies his method, are not mathematically measurable qualities, and his results, self-consistent though they are, are scientifically untrustworthy because of variation in the standard of popular judgment in such matters. Stature, however, comes properly within the range of his method, and Mr. Galton has made the most of this point.

The method employed by Mr. Galton may be styled a mathematical interpretation of the law of uniformity of nature as apparent in the tendency of progression and regression to an average for all new examples of measurable qualities. (By the way, it is curious that Mr. Galton does not employ the term progression, instead of making regression cover all movements both upward and downward to an average. Rise to an average is certainly progress.) The comparatively easy method of average in dealing with such problems as heredity in the lump is hardly, what Mr. Galton claims it to be, the pioneer method in the "science of man" (p. 62). Indeed, the method of chance is infertile in both biology and sociology so far as it mistakes statements of average tendency as in any wise comparable in value to the particular predictions given by inductive inquiry. The continued use of such terms as accident and chance to cover a multitude of undetermined particular causes may be directly hurtful so far as this tends to slur over the patient investigation of special cases. The greatest so-called accidental variations, or "sports," have, of course, their reason in a peculiar conjuncture of influences, and the exact determination of these, specially with reference to stable stocks, would be of the greatest scientific and practical value. The method of chance can never be an aid to progress, for it always fails in particular predictions, and reduces our outlook to the level plain of averages.

In a book on natural inheritance we should expect some thorough treatment of the relation of heredity to other factors, and a clear exposition of how it can be isolated from them in its effect, especially upon stature. But the statistics employed are avowedly statistics of stature and not of heredity: how, then, are the results made to stand not merely for stature but also for heredity? Mr. Galton concludes that his results for stature are really laws of heredity because of the peculiar relations of the ratios obtained (p. 132), and also because the results are confirmed by general deductions from the laws of chance (p. 102). But as to this first point we must regard it as assumed rather than proved that kinship is to be measured by the comparison of ratios of deviations amongst kin. If we knew from other investigations or *a priori* that the influence of heredity on regression is in the numerical order given, then Mr. Galton's results would be merely confirmatory evidence. The laws of heredity must be based on the facts of heredity, or it must be clearly shown by the method of elimination that given results can only be ascribed to heredity. Does Mr. Galton accomplish this? He slurs over other influences than heredity (*e.g.* education, p. 156), or he hastily concludes them to be in harmony with heredity (*e.g.* natural selection, p. 119). He also does not satisfy us on the equal influences of parents in heredity (p. 98), which is a fundamental assumption for his process. That the average regression of the son to the general average of stature is by one-third parental deviation (p. 104) does not, on the face of it, prove anything with regard to transmission of stature. I cannot see that Mr. Galton has clearly shown this ratio to be more than a law of stature as determined by all influences and not by heredity alone. To make the ratios obtained a "measure of family likeness" (p. 132) is certainly unproved till it is shown that heredity alone enters into the data upon which the ratios are founded. It is plain that in any case, whether the cause be heredity alone or heredity plus many other influences, certain definite ratios will be obtained for father, son, brother, &c.

As to the way in which an abstract calculation of the laws of chance confirms Mr. Galton's statistics, it is enough to observe that no evidence is adduced why the results attained should not stand for the multiple "accidents" of environment, nourishment, occupation, heredity, &c., rather than to "accidents" of heredity alone. Mr. Galton fails to prove that his ratios are not the mathematical expression for the operation of the law of frequency of error as applied to the chance operation of heredity plus other agencies, rather than the formula for heredity simple and unadulterated.

But stature is undoubtedly modified by many prenatal conditions which do not come under the head of heredity, and it is certainly modified by climate, nourishment, and occupation. It is quite likely that human dwarfs might be raised upon the same principles as the Japanese dwarf trees. Mr. Galton makes no deduction from his statistics for other influences than heredity, and his results stand as the expression of the law of frequency of error applied to qualities which are the effect of many complex causes beside heredity. HIRAM M. STANLEY.

Lake Forest University, October 5.

Head Measures at Cambridge.

I AM pleased to be able to say, with reference to criticisms by your correspondents on the trustworthiness of the head measures at Cambridge, and on the deductions made by myself from the results obtained by Dr. Venn after he had discussed the first batch of them, that he is now about to discuss a second batch. The observations that have since accumulated are about equal in number to those already dealt with, and the new results will afford an efficient check upon the value of those already published. I hope also that Dr. Venn may find adequate material to determine the "probable error" of a single head measure, by means of the differences (discussed under obvious restrictions) between the recorded measures of the same persons at different times. We shall then be better able than we are now to estimate the degree of reliance to be placed on the mean value of any given number of head measures. FRANCIS GALTON.

Trimorphism in *Scabiosa succisa*.

THIS species is usually described as gynodiœcious. Hooker ("Student's Flora") thus refers to it. Darwin ("Forms of Flowers") says, "I have observed the existence of two forms in our endemic *S. succisa*"; further, "From what Lecoq says ('Géographie Botanique') *S. succisa* appears to occur under two forms in France"; and again, "According to Lecoq, the female flower-heads of *S. succisa* are smaller than those of what he calls the male plants, but which are probably hermaphrodites." Hermann Müller ("Fertilization of Flowers") also speaks of *S. succisa* as existing under two forms in Germany.

I have recently discovered that the species really exists, in this country at least, under three very distinct forms, viz. (1) the original hermaphrodite; (2) the small female form described by Lecoq; and (3) a second female form, larger even than the hermaphrodite, and differing from the first in a very remarkable manner. I will describe the three forms in detail.

No. 1 (hermaphrodite). Average measurements of 100 capitula: diameter at the base $\frac{13}{16}$ inch, height $\frac{17}{32}$ inch. Average number of florets per capitulum 86 (highest 111, lowest 53). Corolla lavender. Filaments incurved in bud, afterwards erect, and twice as long as the corolla-tube. Anthers pink. Style about $\frac{7}{16}$ inch long, thin, remarkably erect, purple, glabrous. Plane of stigma at right angles to the style. Development of style does not take place till anthers have fallen, when stigma becomes viscid.

No. 2 (straight-styled female). Average measurements of 50 capitula: diameter $\frac{5}{8}$ inch, height $\frac{3}{8}$ inch. Average number of florets 61 (highest 79, lowest 52). Florets very small. Corolla with a deep lilac tinge. Stamens abortive, filaments very short, within the tube. Rudimentary anthers yellow. Style about $\frac{3}{8}$ inch long, otherwise precisely as in No. 1, but development begins as soon as the floret opens.

No. 3 (bent-style female). Average measurements of 150 capitula: diameter $\frac{7}{8}$ inch, height $\frac{9}{16}$ inch. Average number of florets 58 (highest 79, lowest 22). Florets very large, and more loosely packed on the receptacle. Corolla blue, with a lavender tinge. Stamens as in No. 2. Style about $\frac{9}{16}$ inch long, very stout, much swollen at the base (? honey-gland), usually white, stigma green. Plane of the stigma much inclined. Styles much bent and twisted. The whole surface of the corolla clothed with long stellate hairs. These are thickest on the face of the limb, which in the other forms is quite glabrous. The style is also thickly covered with similar hairs, which are much crowded immediately below the stigma. To these hairs an immense number of pollen-grains may be found adhering. The hairs are not fully developed until the stigma is mature.

Forms in some respects intermediate between Nos. 1 and 2, and between Nos. 1 and 3, are occasionally found, and this might be expected, as Nos. 2 and 3 are obviously descended from the hermaphrodite No. 1. I have never, however, found a single individual in any sense intermediate between Nos. 2 and 3, which appear to be two distinct female forms developed from No. 1 along different lines.

These two forms, it will be observed, differ remarkably from each other in the following points, viz. size of capitulum, size of florets and arrangement on the receptacle, colour of corolla, stoutness, colour and general form of style, and in the absence or presence of stellate hairs.

The stellate hairs are utilized to catch stray pollen-grains detached from the bodies of insect-visitors coming from neighbouring hermaphrodites, most of which would otherwise be wasted. As it is, they are retained by the hairs until the arrival of other insects, which in depressing the already bent and twisted styles bring their viscid stigmas into contact with the pollen-grains collected by the hairs of adjacent florets—a result facilitated by the manner in which the stigma is set on the style. By this arrangement the chances of fertilization are much increased, as each stigma generally receives a full share of pollen.

With regard to the relative size of the three forms it is remarkable that while one of the female forms is so much smaller than the hermaphrodite (as is the case, according to Darwin, in all gynodiœcious species known to him), the other even exceeds it in size. It is also noteworthy that the capitulum of the second female form, although larger than that of the hermaphrodite, contains a much smaller number of florets, and these are very large.

I can discover no rule as to the distribution of the different forms. In one station near here (a large common) all the plants are hermaphrodites. In a certain wood where the species abounds, the "bent-styled" females appear to be nearly as common as the hermaphrodites, while no "straight-styled" females can be found. In another wood, not half a mile distant from the first, the "bent-styled" form is almost entirely supplanted by the "straight-styled," which is plentiful. Lastly, in a fourth station (a barren strip of ground by the roadside), all three forms are found growing together. ARTHUR TURNER.

Box Hill, September.

On the Aquatic Habits of Certain Land Tortoises.

IT has always proved of more or less interest to me to observe the method of aquatic locomotion adopted on the part of any of our strictly terrestrial vertebrates, and never is this more keen than when the opportunity has been afforded to study the swimming propensities of certain of our Reptilia. Most snakes swim well, but who of us has not been surprised upon first observing the violent wriggling, froward-propelling motions of some of the smaller lizards when they are thrown out into the water some little distance from the shore? The American chameleon (*Anolis principalis*) well illustrates this last; and this lizard, in common with others, seems to possess an actual dread of getting into deep water. For a long time it has been known that most species of the so-considered stricter types of land tortoises soon drown when placed in water of any considerable depth, and it would be but natural to suppose that such species would avoid that element as far as possible, but I have found this by no means always to be the case. Take the ordinary land turtle of the United States (*Cistudo carolina*) for example: it will voluntarily enter the water under certain circumstances. Not long ago the writer noticed one of these hunting for food in three or four inches of water along the edge of a pond that had rising banks; and the first time I discovered the nest of this variety the eggs were deposited in the water in a depression at the miry margin of a marsh. But this is not all, for if we place one of these reptiles upon a little island of land, well removed from the shore, and surrounded by water several feet in depth, and withdraw to watch its movements, we note that as soon as it satisfies itself as to its position, it will, without further ado, take at once to the water and swim to the nearest shore. It does not, however, sink beneath the surface, but, holding its head high out of that element, and filling its lungs with air, strikes out vigorously, with alternate pairs of feet, until it accomplishes its purpose, and regains the mainland. How far one could swim in this manner I am unable to state, but that it would not exceed a few yards I am quite certain. Nevertheless, even the power to accomplish the feat to the extent indicated might, under a variety of circumstances, have its influence upon the distribution of the species, or of any species of typical land tortoise, and it would be interesting to know how far this power may be enjoyed by this class of reptiles generally.

Smithsonian Institution, R. W. SHUFELDT.
Washington, D.C., September 13.

Delambre's Analogies.

FOUR of the most important formulæ in spherical trigonometry were given by Gauss, without proof, in his "Theoria Motus Corporum Cœlestium" (1809), and were therefore called Gauss's theorems or analogies.

They were, however, given by Mollweide in Zach's *Monatliche Correspondenz* for November 1808, and before that by Delambre in the *Connaissance des Temps*, issued in April 1807, so that they are now justly ascribed to the latter.

They may be deduced in the most simple manner from Napier's analogies, and thus easily remembered.

Napier's analogies are—

$$\tan \tfrac{1}{2}(A + B) = \frac{\cos \frac{1}{2}(a - b)}{\cos \frac{1}{2}(a + b)} \cdot \cot \tfrac{1}{2}C \qquad (\alpha)$$

$$\tan \tfrac{1}{2}(A - B) = \frac{\sin \frac{1}{2}(a - b)}{\sin \frac{1}{2}(a + b)} \cdot \cot \tfrac{1}{2}C \qquad (\beta)$$

$$\tan \tfrac{1}{2}(a + b) = \frac{\cos \frac{1}{2}(A - B)}{\cos \frac{1}{2}(A + B)} \cdot \tan \tfrac{1}{2}c \qquad (\gamma)$$

$$\tan \tfrac{1}{2}(a - b) = \frac{\sin \frac{1}{2}(A - B)}{\sin \frac{1}{2}(A + B)} \cdot \tan \tfrac{1}{2}c \qquad (\delta)$$

$$\text{Let } m \cdot \sin \tfrac{1}{2}(A + B) = \cos \tfrac{1}{2}(a - b) \cos \tfrac{1}{2}C \,. \qquad (1)$$

$$\therefore\ m \cdot \cos \tfrac{1}{2}(A + B) = \cos \tfrac{1}{2}(a + b) \sin \tfrac{1}{2}C \,. \qquad (2)$$

These are numerator and denominator of (α).

$$\text{Let } n \cdot \sin \tfrac{1}{2}(A - B) = \sin \tfrac{1}{2}(a - b) \cos \tfrac{1}{2}C \,. \qquad (3)$$

$$\therefore\ n \cdot \cos \tfrac{1}{2}(A - B) = \sin \tfrac{1}{2}(a + b) \sin \tfrac{1}{2}C \,. \qquad (4)$$

Numerator and denominator of (β).

Square, and add—

$$\therefore\ m^2 + n^2 = 1.$$

Divide (4) by (2), and it follows by (γ) that—

$$\frac{n}{m} = \tan \tfrac{1}{2}c;$$

$$\therefore\ m = \cos \tfrac{1}{2}c,\ n = \sin \tfrac{1}{2}c.$$

Substitute these values, and (1), (2), (3), (4), are Delambre's analogies. R. CHARTRES.

Classified Cataloguing.

THE principle suggested by Mr. Petrie, on "Classified Cataloguing" (NATURE, August 22, p. 392), is already successfully used in many of the chief libraries of the United States, having been originated by Mr. Melville Dewey, while Librarian at Amherst College. It is equally applicable to collections of all kinds, and the classification has already been extended to a considerable extent in certain departments, particularly in botany, and is capable of unlimited extension. It possesses all the advantages mentioned by Mr. Petrie, but is broader, inasmuch as it includes all subjects.

In the "Decimal Classification" of Mr. Dewey (Boston, 1885, second edition), we find, for illustration, under 500, General Science; 580, Botany; 583, Dicotyledonæ; 583·9, Apetalæ; 583·95, Unisexuales, 583·951, Euphorbiaceæ; 590, Zoology; 598, Reptiles; 598·13, Chelonia, &c.

If an extension of this system, which would, I have the means of knowing, be most acceptable to Mr. Dewey, were to be adopted for general museum use, the advantages would be incalculable. JAS. LEWIS HOWE.

Polytechnic Society, Louisville, Kentucky.

Valuable Specimens of Vertebrates for Biological Laboratories.

WHAT specimens of Vertebrates are the best to be used by the student in the biological laboratory? This is certainly a very important question. In Europe, the following animals are generally dissected: some fish, the common frog, the pigeon, the rabbit, or the guinea-pig. The frog is a very aberrant member of the Batrachia, and it would be very instructive for the student to examine a more typical representative of the class. Such a one is the American Proteus (*Necturus maculatus*, Ref.), used at Cornell University, Ithaca, N.Y. During the last few years I have received many specimens of Vertebrates from two fishermen—Mr. Russell Dee and Mr. F. C. Audibert, from Marietta, Ohio. Lately, Mr. Audibert has written to me that he could procure any quantity of material, if wanted, and he would charge only 25 cents. (a little over one shilling) for each specimen. From the list of specimens sent to me by Mr. Audibert I select the following, which appear the most important for laboratory use :—

Accipenser maculosus, Les.
Polyodon folium, Lat.
Lepidosteus osseus, L.
Necturus maculosus, Ref.
Menopoma alleghaniensis, Daud.
Trionyx muticus, Les.

The instructive value of these specimens is certainly very great, and the low price could enable any biological laboratory to secure this material. G. BAUR.

New Haven, Conn., September 30.

"Darwinism."

IT has now become to me a matter of amusement to note how those naturalists who of late years have drifted most widely from the doctrines of evolution as these were held by Darwin, habitually accuse me of Darwinian heresy because I have not seen any adequate reason to depart from those doctrines in their entirety. Perceiving that there has been some change of relative position, while failing to perceive that the movement has been altogether on their own side, these naturalists represent that I have been falling away from Darwinism, when the fact is that they have been advancing beyond anything that was ever countenanced by the judgment of Darwin—and even expressly accepting the view which he so vehemently rejected, viz. that of regarding natural selection as the sole cause of organic evolution. Thus, for example, when in NATURE of October 10 (p. 569) Prof. Ray Lankester gravely designates my paper on physiological selection a "laborious attack upon Darwin's theory of the origin of species," it becomes evident how fast and far he has travelled from his Darwinism of two or three years ago. For, to put it briefly, unless it can be shown that Darwin considered natural selection the only possible cause of organic evolution, and did not consider sterility between allied species as probably due to some other principle of change, it is obvious that there *can* be nothing in my "additional suggestion on the origin of species" which may in any sense be designated an attack upon the distinctively Darwinian theory. Yet it is with regard to these very points that the opinion of Darwin was steadily opposed to that of Wallace; *i.e.* to the present opinion of Lankester. Therefore, quite apart from any question touching the truth of this "additional suggestion" or "supplementary hypothesis" (which, however, I may here parenthetically remark, will soon be shown to be in no way seriously affected by Mr. Wallace's sole remaining criticism), it is sufficiently evident that, when the object of publishing the hypothesis was expressly and repeatedly stated to have been that of meeting the main difficulties which had been advanced against the theory of natural selection, the present designation of this hypothesis as an elaborate attack upon that theory is simply absurd.

But my object in now writing is to state, *apropos* of Prof. Lankester's remarks on the inadequacy of Mr. Wallace's criticism of Mr. Gulick's paper, that I have just received a communication from the latter gentleman (who writes from Japan), requesting me to exercise my discretion as to publishing in these columns a reply to that criticism. Unfortunately this reply is too long for insertion, and as I do not see how it can be curtailed without serious detriment, I have refused to incur the responsibility of publishing it in an abbreviated form. At the same time it seems but just to let the readers of NATURE know that a full reply to Mr. Wallace's criticisms (in these columns and elsewhere) has been prepared; since otherwise the silence of its author might be misinterpreted.

To me it appears that Mr. Gulick's work is much the most profound that has ever been published on the important matters of which it treats (viz. isolation in all its forms, with its consequences in "segregate breeding" and "divergent evolution"); and therefore I am glad to take this opportunity of recognizing his priority, by some fifteen years, in thinking out, and largely verifying by his researches on land shells, the theory of physiological selection. GEORGE J. ROMANES.

Geanies, Ross-shire, October 12.

Sunset Glows.

IT is a curious fact that a revival of sunset-glows, similar to those described by Sereno E. Bishop in a letter published in NATURE for August 29 (p. 415), was observed in Western New York at almost precisely the same time that he saw them at Honolulu. I inclose a clipping from the *Rochester* (N.Y.), *Democrat and Chronicle*, which was published on July 21 :—

"The skies at evening show signs of the gradual return of the red light. It will be of interest to ascertain if the phenomenon reappears as the solar disturbances continue to increase in energy to the maximum. It is quite apparent now that the minimum has been passed, and the tendency is toward an increase in the number and in the violence of solar disturbances. There are certainly three and probably four well-defined disturbances at present." M. A. VEEDER.

Lyons, New York, September 13.

"The Teaching of Science."

I BEG that the following alterations may be made in the "Suggestions for a Course of Elementary Instruction in Physical Science," printed in NATURE of October 17.

HENRY E. ARMSTRONG.

P. 602, Problem II., line 11 from above, read "by means of iron" instead of "by means of phosphorus."

P. 603, Problem VII., line 20 from below, instead of "when metals are heated with acids," read "when metals are dissolved in acids."

P. 604, Problem IX., line 31 from above in right-hand column, read "dried hydrogen," instead of "dried oxygen."

P. 605, Problem XII., line 17 from above in right-hand column, read "zinc oxide," instead of "lime oxide."

TELESCOPES FOR STELLAR PHOTOGRAPHY.[1]

II.

IN considering the essentials of a good system of control for equatorial clocks, it is necessary to keep in view the exact conditions required. It is not sufficient that the controlling apparatus (of whatever form it may be) should simply bring the *rate* of the clock, which has been interfered with by some adventitious disturbance, correct once more ; it must do more, it must correct this error. For, suppose a star be set on the slit of a spectroscope, and the clock started, and say, as in Dr. Huggins's case, a photographic plate inserted for a two hours' exposure. Now suppose that five minutes after the commencement of the exposure, an error of one-tenth or two-tenths of a second occurs from some disturbing cause (a fragment of dirt on the tooth of a wheel, or other cause) ; if the controlling apparatus be of such a nature as simply to bring the clock-rate correct again, the position of the telescope will be the above quantity, one-tenth or two-tenths of a second, in error for the remainder of the exposure, although the rate may be absolutely correct for the whole times. In other words, the star will have moved off the slit, by a quantity equivalent to what the instrument would move in one-tenth or two-tenths of a second, and will continue off the slit for the remainder of the two hours. So it will be seen that no controlling apparatus is of any use whatever, unless, as well as keeping the rate uniform, it corrects the errors that have crept in. In consequence of not keeping this point in view, many most ingenious but useless arrangements have been from time to time proposed. A little consideration will show that this arrangement meets all requirements.

The above arrangement is somewhat similar to Dr. Gill's.

[1] A Paper read by Sir Howard Grubb, F.R.S., before the Society of Arts, on April 18, 1888. Continued from p. 444.

It is simpler to attach to any existing clock, but not so delicate as his, and is open to the same objections. It is, however, capable of very good work, as may be judged from the chronograph sheet of the Dunsink Observatory chronograph.

The third is the form of control which I devised for Mr. Isaac Roberts, and which has been so successful with him, and with Prof. Pritchard (who has had it recently attached to the Oxford equatorial), that photographs have been exposed with the telescope to which it has been attached for fifteen minutes, and yielded perfect images of stars without any hand and eye guiding.

The arrangement consists, firstly, of a *remontoire* train, driving a good mercurial or other compensated pendulum—the driving of this train being of course entirely independent of the equatorial clock giving motion to the telescope; secondly, of a detector apparatus, which detects any difference between the rate of this standard pendulum and the equatorial clock; and thirdly, of a correcting apparatus, which corrects automatically any error discovered by the detector. This corrector itself consists of two parts—an "accelerator" and a "retarder"—and these we will first proceed to describe.

In S S′ S″ is one of the shafts, between the driving train of the equatorial clock and the worm which drives the right ascension sector, this shaft being cut into three parts, denoted by the letters just named. At one end the portion S of the shaft carries a wheel, 1, immediately adjoining which is the wheel 2, mounted on the portion S′ of the shaft. At the other end of this last-named section of the shaft is fixed a third wheel, 3, which is almost in contact with the wheel 4, fixed on the end of the shaft S″. The shafts S and S′ also have mounted freely on them the brass disks, *d d′*, which adjoin the two pair of wheels referred to above. Each of these brass disks is furnished with a stud on which a small pinion is mounted, the pinion *p*, belonging to the disk *d*, gearing across the pair of wheels, 1–2; while the pinion *p*, belonging to the disk *d′*, gears across the pair of wheels, 3–4.

Under normal conditions, if no error exists in the equatorial clock rate, the arrangement of wheels and pinions just described revolves as one piece, the three sections, S S′ S″, of the shaft rotating at the same speed; but it is possible by an arrangement which we shall explain presently, to stop the rotation of either of the disks, *d d′*, and as soon as this occurs the pinion of the stopped disk has to act as a transmitter of motion from one of the wheels into which it gears to the other. If the two wheels of each pair had the same number of teeth, the speed of both wheels would still remain the same, but in reality the number of teeth in the two wheels of each pair is different, and hence the stopping of one of the disks, *d* or *d′*, causes a variation in the rate of rotation of the two adjoining wheels relatively to each other. For instance, in the case of the first pair of wheels, let wheel 1 have 30 and wheel 2 have 29 teeth, and suppose that the shaft S is rotating once every 60 seconds. Thus, if the disk *d* be stopped, the wheel 2 will be made to revolve in $\frac{29}{30}$ of the time occupied by the wheel 1, or in other words the rate of the section S′ of the shaft will be accelerated to one revolution in 58 seconds. In the same way by reversing the positions of the wheels in the other pair 3–4, the stoppage of the disk *d′* can be made to effect a retardation of the portion S″ of the shaft relatively to S′. The edges of the disks *d* and *d′* are cut into very fine teeth, and the stoppage of the disks when desired is effected by causing a comb attached to the armature of an electro-magnet to engage with these teeth.

The whole apparatus just described constitutes a very convenient arrangement for accelerating or retarding the driving motion imparted to the telescope by the equatorial clock, and that it is capable of very good work is shown by the photographs which have been taken by Prof. Pritchard and Mr. Roberts, in which the star disks are perfectly round, though exposed for 15 to 60 minutes, and no hand guiding used.

I have now to describe how this apparatus is, when necessary, automatically brought into action by the "detector."

In Figs. 5, 6, and 7,[1] W is a scape-wheel mounted on the sixty-second spindle of the controlling clock, and driven from that spindle through a spiral spring, X X, so that no error in the equatorial clock can affect its rate or that of the standard pendulum. On the same spindle there is also mounted behind the scape-wheel an ebonite disk, E E, Fig. 5; this disk, which is driven by the equatorial clock, carrying two insulated rings, *b b′*, which are respectively connected metallically with two platinum plates, B B′, inserted in the face of the disk. Between the scape-wheel and the ebonite disk there is also mounted loose on the spindle a lever, A A, which carries at one of its ends a platinum bridge, B, which is of such a length as to fit between the platinum plates, B B, and which in its mid-position bears against a piece of rock crystal let into the ebonite disk between the two plates just named. At the other end the lever, A A, is formed into a fork, between the arms of which projects a pin carried by the scape-wheel; the arms of the fork are provided with set screws,

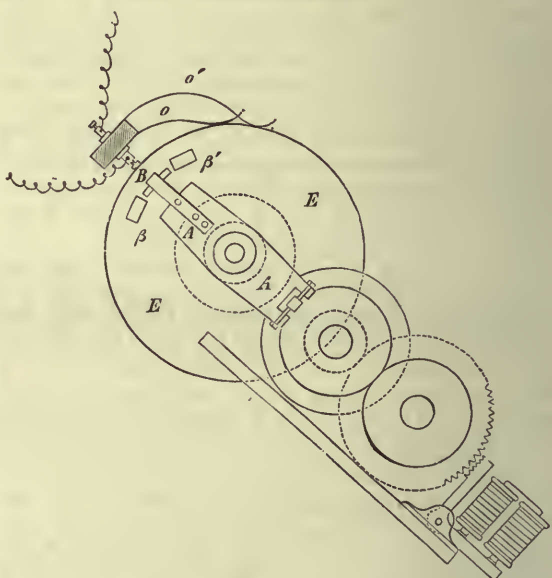


FIG. 5.

by means of which the amount of play allowed to this pin in the fork can be adjusted.

The insulating rings, *b b′*, are electrically connected with the accelerator and retarder already described by means of fine platinum wires, O O′, wiping against them, and the action of the whole arrangement is as follows. The scape-wheel, W, being driven by the control clock, has an intermittent movement corresponding to the beats of the pendulum, while the ebonite disk, E E, being driven by the equatorial clock, has a constant movement, so that even if the scape-wheel and disk make a whole revolution in the same time, the pin carried by the scape-wheel will be constantly oscillating between the pins of the fork at one end of the lever, A, this lever being driven by friction from the ebonite disk. The pins just named are adjusted so as to allow of this oscillation taking place without interference, so long as the rates of the equatorial and control clocks remain uniform, but if the equatorial clock either loses or gains with respect to the standard, the pin on the scape-wheel comes into contact with one of the fork pins of the lever, A, and shifts that lever on the spindle, bringing the bridge, B, into contact with one of the platinum plates,

[1] These blocks have been kindly lent by the editor of *Engineering*.

B or B′, and transmitting a current which brings into action the accelerator or retarder as may be required. The period during which the accelerator or retarder remains in action will depend upon the amount of the error to be corrected, and the proportions of the pairs of wheels, 1, 2, and 3, 4. With the proportions described above, the correction introduced is one-thirtieth of the rate, so that, to correct an error of one-fifth of a second, the accelerator or retarder, as the case may be, would have to remain in operation $\frac{30}{5} = 6$ seconds. As soon as the correction has been made, the lever, A, will resume its normal position, and the bridge, B, coming then between the two platinum plates, B B′, a current will cease to be transmitted, and the accelerator or retarder thrown out of action.

It is to be noted that the apparatus above described not only corrects any temporary disturbance of the equatorial clock rate, but cancels errors which have already occurred.

It will be seen that the third form of control is free from the objections of the first and second. The detector part of the apparatus is close to the screw spindle, only removed from it by one pair of wheels, and the correction is not applied in the same manner by checking the speed of the clock, but by introducing a differential gear, which acts until the error be cured, and then drops out of gear automatically.

The fourth and last form of control, however, is that to which I would invite your special attention, for I believe it to be capable of results beyond all the others.

I have endeavoured in it to select all the good points of the other forms, and to combat the weak points. I may not have as yet produced it in as perfect a form as is possible, but I am satisfied it is capable of development into a very perfect control, and even at present it is the most perfect I have constructed.

As long as the control applied its correction by altering the speed of the governor, it was necessary to keep down the *vis inertia* of the governors, but now, as the correction is not applied in this way, I have made the governor very heavy, and running at a very high speed.

The *vis inertia* of the governor is represented by some 10,000 foot-pounds per minute; consequently it is little affected by any small or short differences in friction or driving powers.

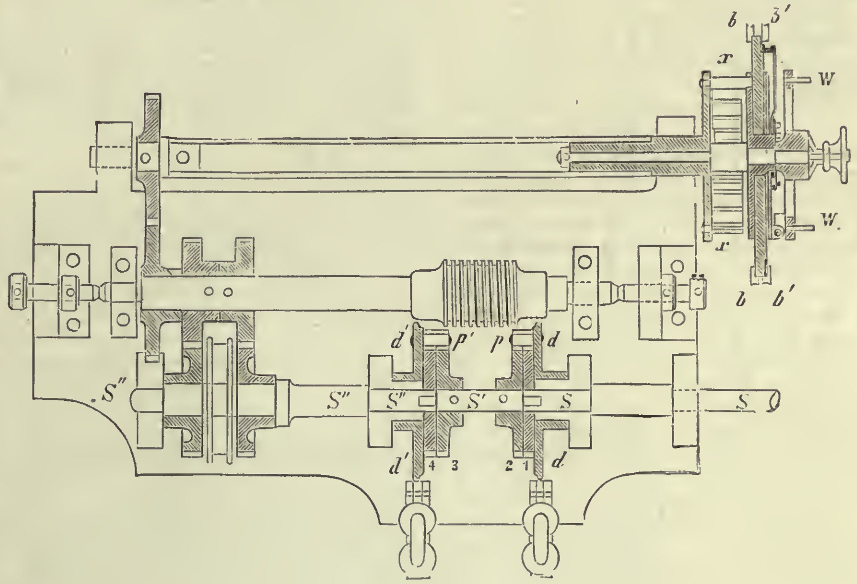


Fig. 6.

Again, at the suggestion of Dr. Gill, I make the governor spindle gear directly into the counter spindle of the screw, in order to have as few wheels and pinions to deal with as possible. Errors of wheels behind the governors have nothing whatever to do with the accuracy of its rate.

As to the nature of the control, I use Dr. Gill's form of detector and my own form of corrector, viz. accelerator and retarder. I use Dr. Gill's detector because it seems to be capable of being made on a larger scale than mine, and consequently ought to be more delicate.

I now propose to say a very few words on the optical part of the instrument.

The first question that naturally occurs is whether a refractor or reflector should be used. I own that when I first considered the subject I inclined to the belief that reflectors would be found to be the most suitable; and in a paper of mine, which was read before the Royal Astronomical Society last spring, I urged that comparative trials should be made before a final decision was arrived at. I have found reason, however, to modify my views on this point.

My reason for thinking that the reflector might possibly prove the best was founded on the consideration that in reflecting instruments rays of all refrangibilities are brought to a focus at one and the same point, whereas in the refractor rays of various refrangibility have different foci, and the best we can do is to so arrange the curves that those rays most active in impressing the photographic plate may be brought as nearly as possible to the one focus.

If we draw a curve which represents the position of the focal point for various rays of the spectrum in an object-glass corrected for photo work, it will be something like this figure (Fig. 8). The same for a reflector will be represented by a straight line. Looking at these curves it is certainly a natural conclusion that the reflector ought to be best, and therefore it was that I urged that a fair comparative trial should be made between the reflector and refractor as to their suitability for this work.

The Congress, however, decided upon the use of refractors, from the simple fact (as Dr. Gill says) that the best work done (to that time) had been done by refractors, not taking into consideration the very much more favourable conditions under which the refractor photographs were taken. Since that time further experiments have been made with both forms of instruments, which tend to show that, as against the refractor of the ordinary construction, the reflector can well hold its own, but that while it is obviously impossible for the optician to improve the field of the reflector, it is by no means impossible to do so with the refractor, and time and patient experimenting have shown that, by a modification of the curves of an objective, equally good definition of the central pencil can be obtained, combined with a very much better and flatter field, so that, however well reflectors could compete with the ordinary form of refractor, they cannot do so with forms constructed with special reference to field.

It should be borne in mind that the question of field is one which the optician was never before asked to consider

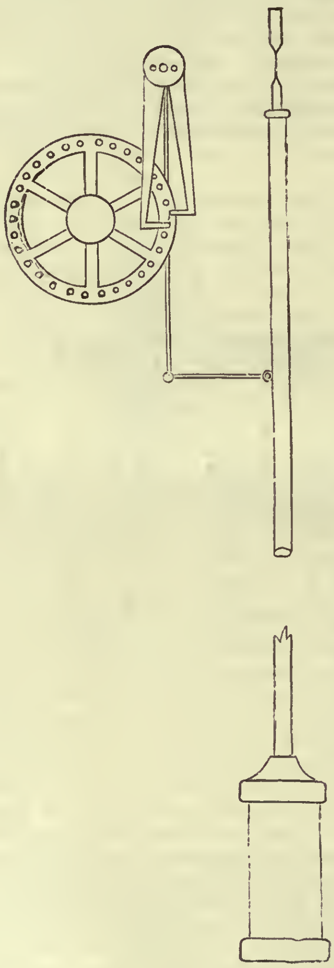


Fig. 7.

in telescope objectives. The field of such a sized telescope used for visual work would not be more than $\frac{1}{2}°$, even with the lowest power. It has been found possible to obtain good definition over a field of 2° with either reflector or the ordinary form of refractor, and with the modified form considerably more. This question of field is, as I said, a very important one, for on it depends the amount of time required to complete the survey. If one instrument gives equally good definitions over 3° square, *i.e.* nine square degrees, as another does over 2° square, *i.e.* four square degrees, it is evident that the first instrument, equally energetically worked, is capable of completing the survey in less than half the number of years it is possible to do with the second instrument.

There is one point connected with this question of field which is of great importance.

Various forms of objectives give various characters of images of star disks at the edge of the field. Some give a bright nucleus with a tail like a comet, some assume a form approaching to a cross, and some give elliptical disks.

Of course perfection would mean absolutely circular disks all over the plate, but when this cannot be obtained, the last or elliptical disks are very much preferable to either of the others. It is quite possible to fairly estimate the most central point in an ellipse if the illumination over it be tolerably equal, but in the case of the comet or irregular form this is not possible.

The newer forms of objectives are peculiar in that the distortion of the lateral star images are of their least objectionable character.

It has been suggested that good results might be obtained by using the new "Jena" glass with rational spectra, but I have made inquiries respecting this, and it is not considered by the makers themselves that this glass in its present state would be suitable for the purpose of these photographic objectives. Until the permanency of that glass be thoroughly tested by exposure to various climates for some years, it does not appear safe to use it for such important work as this. There can be little doubt, however, that for ordinary visual work this glass, if capable of being made into large disks, will allow of the production of objectives superior to anything hitherto made.

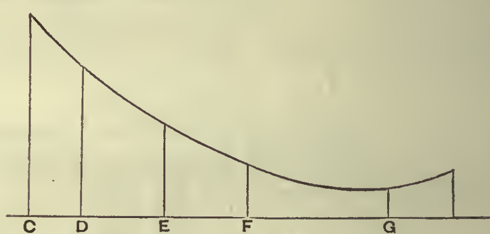


Fig. 8.

I ought perhaps to mention that it is possible to make an objective which can be adjusted to work either as a photographic or visual objective.

By separating the lenses of an ordinary objective, the chromatic correction can be so much reduced as to render it suitable for photographic work, but unfortunately the spherical aberration is reduced at the same time and definition destroyed.

Prof. Stokes, however, suggested to me that by constructing an objective in such a manner that the crown lens would be unequally convex by a certain amount, and that the spherical aberration would be correct when the flatter side was outermost, that then the chromatic aberration could be reduced as before by separating the lenses, and the reduced correction for spherical aberration raised by turning the crown lens with its more convex side outerwards.

This I tried, and found act perfectly.

I described this last spring at the Royal Astronomical Society, but it has since been re-invented in America.

It remains for me now only to describe how these new photographic objectives are tested.

The testing of objectives for visual work is a matter almost altogether of eye experience.

In these photographic objectives a different course must be adopted, as the image appears to be badly corrected to the eye when it is rightly corrected for photographic rays.

The Paris Congress decided that the rays G of the spectrum should have in their objectives a minimum focus; how is the correction to be verified? It is usual in the testing of the chromatic aberration of objectives, by those whose eye experiences cannot be a sufficiently accurate guide, to allow the image of a star, as found by the objective, to fall on the slit of a spectroscope, and to judge of the focus of each particular ray by the breadth of the spectrum at that ray. Wherever the light is brought to a focus the spectrum is of insensible breadth. When it is out of focus, a more or less sensible breadth, by moving the spectroscope in and out of the position of maximum and minimum foci, can be obtained.

I tried this plan, but found it very unsatisfactory, as it was very difficult to determine the exact place where the spectrum was narrowest, the curves being so very shallow.

After much thought I arrived at the following very simple and efficient plan, which I described in full, as it may be useful to some for other purposes. It should be remembered that the object is to get the focus of the objective for various parts of the spectrum.

If, therefore, we could obtain various objects when light was derived for such portions, and such portions only, of the spectrum as we required, our object would be accomplished.

I take a spectroscope with a fairly large dispersion equal to about 2 prisms of 60° and with a pencil of light of about 2° diameter. I remove the observing telescope, and substitute one of very long focus, so that the linear dimensions of the spectrum shall be as large as possible. I observe with this the solar spectrum, and note the position of such lines as I intend to work on. I then remove the eye-piece and insert in its place a tube carrying a small convex mirror. The apparatus is left till dark, and a small electric glass lamp attached outside the slit. The observing telescope is then placed at such a reading as I know will bring any certain line into the centre of the field, and on looking at the small mirror through a long slit which is purposely made on the top of the tube to allow it to be viewed from the front, you see a small bright star whose light is due to that particular line in the spectrum, and to no other part. The apparatus is placed at a sufficient distance in front of the photographic telescope, and these stars are the objects examined. In this way I can produce a small bright star of a colour corresponding to any of the lines in the spectrum, and the foci of these, as observed in the photographic telescope, can be measured with great exactitude.

There are, of course, small matters of detail which I have been unable to touch upon in the present communication, many of which are very important for the effective working of these instruments, and which require special treatment. I have, however, confined myself to the principal and more important parts, but I trust that I have been able to show that we have at least made a substantial advance; and it remains for us to hope that when these instruments are placed in the hands of astronomers they may yield a rich harvest of work, and leave their mark on the history of astronomical science.

HOWARD GRUBB.

ON THE PRINCIPLE AND METHODS OF ASSIGNING MARKS FOR BODILY EFFICIENCY.[1]

THE question to be solved is of this kind. Suppose that one man can just distinguish a minute test object at the distance of 25 inches, another at that of 35, and again another at 45 inches, how should we mark them? We should be very rash if we marked them in the proportion of 25, 35, and 45, or even if, for some good reason, we had selected 25 as the lowest limit from which marks should begin to count, we should mark them as 0, 10, and 20.

[1] Read at the British Association, by Francis Galton, F.R.S.; but slightly revised, in order to introduce the diagrams herewith printed. Followed by remarks on experiments made at Eton College, by A. A. Somerville.

Two separate considerations are concerned in the just determination of a scale of marks—namely, absolute performance and relative rank, which are apt to be confused in unknown and varying proportions.

Absolute performance is such as is expressed by the 25, 35, and 45 inches just spoken of. It is perfectly correct in some cases to mark, or let us say to pay, for this, and this alone, upon the principle of piece-work—namely, that the pay ought to be proportionate to the work accomplished, or to the expected output in after life.

Relative rank is, however, on the whole, a more important consideration than the absolute amount of performance by which that rank is obtained. It has an importance of its own, because the conditions of life are those of continual competition, in which the man who is relatively strong will always achieve success, while the relatively weak will fail. The absolute difference between their powers matters little. The strongest even by a trifle will win the prize as completely as if he had been strongest by a large excess. Undertakings where many have failed, are accomplished at last by one who usually is very little superior to his predecessors, but it is to just that small increment of absolute superiority that his success is due. Therefore it is clear that relative rank has at least as strong a claim for recognition as absolute performance, if not a much stronger one. They have each to be taken into separate consideration, and each to be separately marked. The precise meaning intended to be conveyed by the phrase "relative rank" will be better understood further on.

Recurring to the example of keenness of eyesight, let the test object be words printed in diamond type, and the persons tested be Englishmen of the middle classes, between the ages of 23 and 26, then the performance of readtng diamond type at 25 inches happens to be strictly mediocre. Fifty per cent. of the many persons who were tested performed better than this, and 50 per cent. performed worse. The 35-inch performance was exceeded by only 2½ per cent. of the persons tested; and as to the 45-inch performance, it has not in my experience been reached at all. I have had altogether 12,000 persons tested in this way, of both sexes and of various ages, but not one of them has succeeded in reading diamond type at the distance of 45 inches. It is very rare to find one who can do so at 40 inches. Wherever superiority in eyesight is eminently desirable, it would be absurd to make the marks for the three supposed cases to run proportionately either to 25, 35, and 45, or to 0, 10, and 20. The achievement of 45 inches would deserve much higher recognition. Relative rank and absolute performance should not be confused together.

I use the term relative rank in a large sense, with reference to all persons who have been, or are likely to become, candidates, and not to the small number of them who may happen to be present at a particular examination. Statistical tables concerning the class of persons in question have to be compiled from past examinations, and the rank of the individual has to be determined amidst these. I have often described how this is to be done ("Natural Inheritance," p. 38, Macmillan and Co., 1889), but the diagram (Fig. 1) is, I think, the simplest of all forms for the use of an examiner. It tells at a glance the rank held by a man among his fellows in respect to any single and separate faculty. The class from which it is constructed might consist of any large number of persons subject only to the condition that the distance between the limits *within which* it extends shall be always divided into centesimal grades; that is to say, running from 0° to 100°. The grades are printed along both the top and the bottom of the diagram, and refer alike to every line. As a specimen of the way to read it, let us take the line of keenness of eyesight among the males. Here we see that the performance of reading diamond type at the distance of 25 inches is appropriate to grade 50°; or, as already stated, 50 per cent. of all the persons tried did worse, and 50 per cent. did better. Therefore the performance in question is exactly mediocre. Again, 30 inches corresponds to grade 80°; in other words, 80 per cent. did worse and the remaining 20 per cent. did better. The method on which this diagram is constructed is of universal application. Calling the particular class of persons to which it refers, for brevity, by the letters I.H.E. (International Health Exhibition), then the rank of any individual among the I.H.E. males, aged 23-26, in respect to any of the qualities therein named, can be most easily ascertained; also among the I.H.E. females of the same ages.

This method admits of being extended in more than

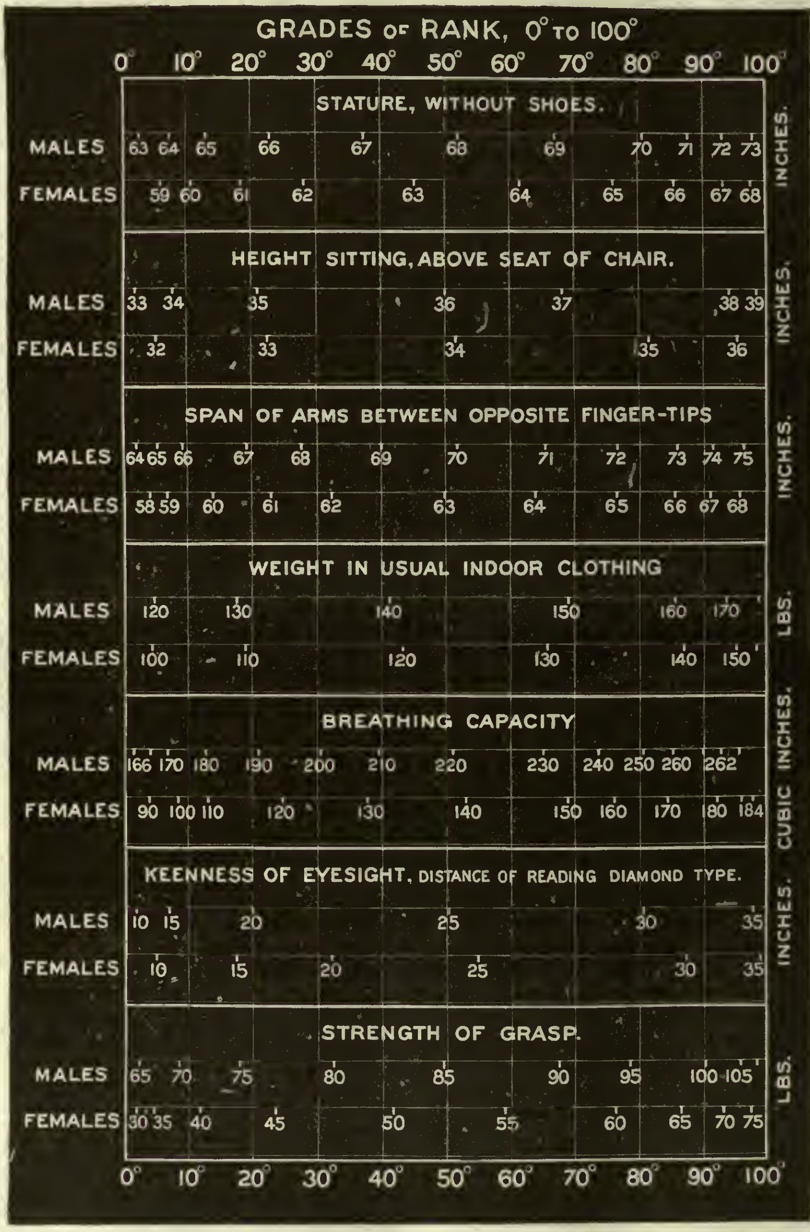


Fig. 1.

one way. That for which there is most call is where the rank of the quality immediately in question, has to be considered in reference to some other quality. Thus it is of little use to know the breathing capacity of the man unless we also know his stature or his weight. Lungs capacious enough to enable a small man to labour violently without panting would be wholly insufficient for the ordinary purposes of a giant, just as an excellent little boiler for a small steam-engine would be ineffective with a large one. The diagram (see Fig. 2) appropriate to the case we are considering, could not be compressed into a single line, but requires many. Successive lines in that figure refer to the successive statures of 60 inches, 61 inches, and so on up to 72 inches. A diagram of breathing capacities for each of these statures was constructed in pencil, on the principle of one of the lines in Fig. 1; then bold lines were drawn from above downward to connect all the pencilled entries of the same value, just as isobars, isotherms, and other contour lines are drawn (to which the general name of *isograms* might well be given). This completed the figure, which hardly needs further description, either how to make or to use it. The importance of taking stature into account now becomes very evident. A breathing capacity of 220 cubic inches in a man of 72 inches stature has the rank of only 6°, but in a man of 60 inches it has the rank of 94°. Fig. 3 shows in a similar way the grade of any given strength of grasp, when the weight of the person is taken into account.

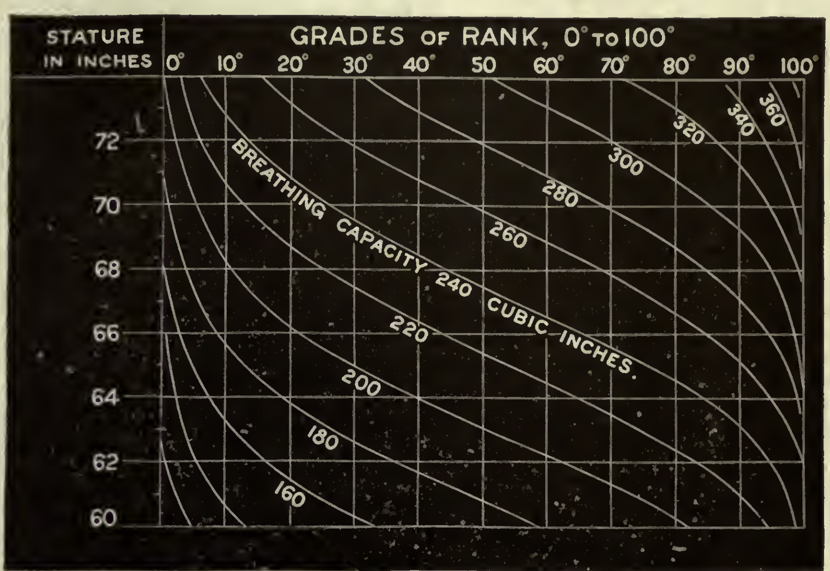


FIG. 2.

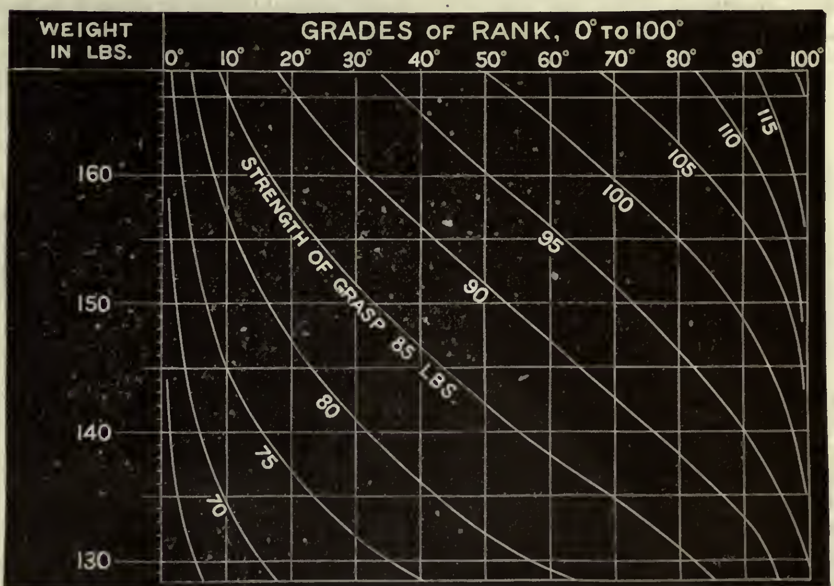


FIG. 3.

When the quality that has to be marked depends upon more than one other quality—as it may be desired to mark breathing capacity with reference *both* to weight and to stature—the simplest plan is to make a separate diagram for each inch or second inch of stature, which is quite near enough. I have, however, contrived to make a single page serve for the whole process by using a sliding strip of paper. I have submitted it for inspection, but do not care to describe it.

A strong reason for giving prominence to relative rank is that it affords the only feasible way of measuring many qualities; differences in absolute performance being inferred from rank, according to a principle now familiar to most anthropologists, by using the well-known table of the probability integral. A small table based on the latter, but of a totally different form, that I have lately more than once published (*op. cit.*, p. 205, and NATURE, vol. xxxix. p. 297). is very convenient for this sort of work. The following is a brief extract from it :—

Grades of Rank from 0° *to* 100°, *together with the Deviations*[1] *from the Mean Values at those Grades.*

Grades.....	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Deviations	– infinity	– 1·9	– 1·3	– 0·8	– 0·4	0·0	+ 0·4	+ 0·8	+ 1·3	+ 1·9
Grades.....	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°
Deviations	+ 2·0	+ 2 1	+ 2·2	+ 2·3	+ 2·4	+ 2·6	+ 2·8	+ 3·1	+ 3·5	+ infinity

Some of the consequences of marking separately the relative rank and the absolute performance are seen by the next table. Here the relative rank is in each case supposed to count between the grades of 50° and 100°. Then, if it alone is considered, a man who stands at the grade of 99° in a class that ranges within the limits of 0° and 100°, will be seen to get very nearly the full amount of ten marks, whereas if absolute performance is alone considered, he would get no more than seven marks. The full number of ten could be never actually reached, but only closely approached at some such high grade as 99·99 . . .°. The figures in this table would have run very differently if the marks for relative rank had begun after 90° and not after 50°. Still more so, if the lower limit had been 99°, and more still if it had been 99°·9. It seems to me most reasonable, on the whole, that they should usually begin after 50°, as in the table :—

Proportion of marks assigned to		Rank, 0° to 100°.				
Relative.	Absolute.	55°	75°	95°	99°	99·99 . . .°
All.	None.	1·0	5·0	9·0	9·8	10·0
½	½	0·7	3·5	6·9	8·4	10·0
⅓	⅔	0·6	3·0	6·2	8·0	10·0
¼	¾	0·5	2·7	5·8	7·7	10·0
None.	All.	0·4	2·0	4·8	7·2	10·0

The general conclusion to which these remarks lead is, that before arranging scales of marks, the first step is to measure a large number of persons who are of the same class as the expected candidates; this has already been done to a considerable extent at Cambridge, at Marlborough College, and elsewhere. Thence to make tables, and to deduce diagrams from them like Fig. 1 in some cases, and like Figs. 2 and 3 in others. These will exactly determine the qualities of the men to be dealt with, in a statistical sense. It is now the part of those who have to fix the scales of marks to determine the grade at which rank shall begin to count, and to arrange the weight to be given respectively to relative rank and to absolute performance in each sort of examination. This and a few other obvious preliminaries having been settled, the construction of consistent scales of marks would follow almost as a matter of course.

Experiments at Eton College on the Degree of Concordance between different Examiners in assigning Marks for Physical Qualifications. By A. A. Somerville.

An experiment was made at Eton in July last, with the object of obtaining information upon the following points: (1) whether it is possible to frame a system of marking for physical excellence, based partly upon Mr. Galton's system, and partly upon medical examination; (2) whether marks assigned by medical examiners would be as safe a test of excellence as those assigned, *e.g.* by examiners in English essay. The experiment was conducted as follows:—A list of points was drawn up with the help of two able medical men. These points were: (1) breathing capacity, as tested by the spirometer; (2) hearing—(3) eyesight, tested by Snellen's type; (4) strength, tested by the grip dynanometer; (5) endurance, tested as follows—after the maximum reading of the dynamometer had been obtained and registered for strength it was again (as nearly as possible) obtained, and the number of seconds during which the candidate could hold the needle of the dynanometer between this reading and the reading 10 below it was taken by a stop-watch; (6) relation of height to weight; (7) girth and shape of chest; (8) general muscular development; (9) health record, particular inquiries being made as to rheumatism, asthma, and scarlatina: (10) general aspect and condition.

The first five points depend solely upon measurement, and consequently the marks of the two doctors are the same for those points. The next point was marked, partly by impression and partly by reference to a table of averages, but it might be made to depend altogether upon averages. The seventh and eighth points were marked partly by measurement of chest, arms, and legs, and partly by examination. The last two points depend altogether upon medical opinion, and involved a thorough medical examination. Ten marks were assigned for each point, and the examination was conducted independently by the two doctors in separate rooms. Thirty-two boys were examined: (1) twenty Army Class boys, including ten successful candidates at the recent Sandhurst and Woolwich Further Examinations, two members of the Cricket XI., and two members of the Rowing Eight; (2) six other members of the XI.; (3) the remaining six members of the Eight. The following table gives the final results, average differences per cent. being calculated with reference to a maximum 50, as the marks for the first five points are the same for the two examiners. (N.B.—Letters are substituted for the names of the boys.)

Army Boys.						Six Members of the XI.			Six Members of the Eight.		
A	58½	58	K	53	56½	A	60	59	A	78¼	79¾
B	74	75¼	L	71½	77	B	59	61	B	73	71½
C	81½	83	M	57	62	C	68¼	71¾	C	76¾	78¾
D	68	69½	N	59½	65	D	77¾	71¾	D	76½	73½
E	72½	70½	O	64	70½	E	58	65¼	E	67	70¼
F	44¾	46¼	P	51½	58	F	64¾	73½	F	71¼	76½
G	65¼	68¼	Q	57	65¼						
H	66½	63½	R	60½	70½						
I	69¼	72¾	S	53¼	62¼						
J	72	76½	T	57	70½						

Army Boys: Greatest difference . . . = 13½; Least difference . . . . = ½; Average difference . . . = 9·5 Per cent.

Six Members of the XI.: Greatest difference . = 8¾; Least difference . . . = 1; Average difference . = 9·5 Per cent.

Six Members of the Eight: Greatest difference. . = 5¼; Least difference . . . = 1½; Average difference. . = 5·5 Per cent.

Average difference for 32 boys . . . . = 4·375 for max. 50
= 8·75 per cent.

Nineteen of the twenty Army boys were subsequently examined in English essay, the essays being marked independently by two examiners, with the following results :—

A	55	50	H	15	10	N	50	25
B	45	50	I	40	60	O	70	35
C	40	35	J	65	40	P	30	65
D	20	25	K	25	15	Q	45	20
E	15	12	L	35	20	R	60	25
F	55	40	M	15	30	S	40	15
G	35	25						

Greatest difference . . . . = 35
Least difference . . . . = 3
Average difference . . . . = 16·7 Per cent.

[1] The unit by which the deviations are measured is half the difference between the performances of the persons who respectively occupy the grades 25° and 75°.

Comparing the average difference, 16·7 per cent., between the marks of the examiners in English essay, with the average difference, 9·5 per cent., for the same boys, between the marks of the medical examiners, it seems fair to conclude that the marks assigned by the latter are at least as trustworthy as those given for English essay, which may be taken as a sample subject in a literary examination.

It is hoped that similar experiments will be undertaken at other places, so that materials may be obtained for the comparison and discussion of different systems of marking, and for the construction, ultimately, of the best systems. Such experiments would be rendered all the more valuable by the introduction of fresh points of examination, and by variations in the method of assigning the marks for the different points.

NOTES.

AT a meeting of the Council of the Royal Society held on October 24, it was resolved that a Committee should be appointed to consider the desirability of raising some national memorial of the late Dr. Joule, and to take such action thereupon as they might think advisable. Sir Henry Roscoe was appointed the provisional Organizing Secretary.

THE Walker Engineering Laboratories in connection with University College, Liverpool, will be opened on November 2. The Lord President and Council of the College will entertain Sir Andrew Barclay Walker, Sir John Coode, the members of the Engineering Committee, and other distinguished guests at luncheon, served in the Walker Laboratories; and in the afternoon a public meeting will be held in St. George's Hall, at which Sir John Coode, President of the Institution of Civil Engineers, will deliver an address, and the annual distribution of medals and prizes will take place. In the evening there will be a reception at the Walker Laboratories, when the formal declaration of opening will be undertaken by the Hon. Lady Walker.

THE annual exhibition prepared by the South London Entomological and Natural History Society was opened at the Bridge House Hotel, London Bridge, S.E., yesterday, and will be open again this evening. These exhibitions have become so popular that on the last several occasions upwards of 2000 visitors have attended each evening.

DR. S. WEIR MITCHELL, of Philadelphia, has been elected President of the Congress of American Physicians and Surgeons, which will meet in Washington in September 1891.

As it is expected that the Forth Bridge will be opened for passenger traffic in the spring of 1890, it is intended that the event shall be celebrated by the holding of an International Exhibition in Edinburgh, specially devoted to electrical and general inventions and industries. The Exhibition is under the patronage of the Queen; and the Marquis of Lothian, Secretary of State for Scotland, is the President. The Vice-Presidents include the Lord Provost of Edinburgh, the Lord Provost of Glasgow, the Lord Mayor (elect) of London, Mr. Edison, and Sir John Fowler. The executive have secured a site of about ninety acres in extent, within easy walking distance of the centre of the town. On Monday, at a special meeting of the Electrical Trades Section of the London Chamber of Commerce, a resolution was agreed to, appointing a Committee to consider the conditions on which it might be advisable to take part in this Exhibition.

A CONVERSAZIONE will be given by the Geologists' Association on December 6.

A STATUE of the French chemist, Nicolas Leblanc, is about to be unveiled at Saint-Denis. Leblanc was born at Issoudun in 1753, and died in 1806. He had a manufactory at Saint-Denis.

THE following Science Lectures will be given at the Royal Victoria Hall during November:—November 5, Mr. A. P. Laurie, on "Dust"; November 12, Mr. W. Furneaux, on "The Heart, and how it beats"; November 19, Prof. Judd, "The Forge of the Blacksmith God"; November 26, Mr. J. E. Marr, "Greenland's Icy Mountains."

THE Morley Memorial College for Working Men and Women, adjoining the Victoria Hall, has begun a very vigorous life. Over 450 students have joined within three weeks of the opening day. In fact they come in with somewhat embarrassing rapidity, and volunteers (both ladies and gentlemen) are urgently wanted, both to teach classes and act as librarians. Six librarians are wanted to take one evening a week each, from 8 to 10. The library has received a valuable present from Mr. Passmore Edwards, who has given 1000 books. Others have given smaller parcels, so that the book-cases which have been provided are quite inadequate, and more are needed.

MR. WILLIAM BURGESS, the founder and proprietor of the Midland Counties Fish Culture Establishment, died on Sunday, at Malvern Wells.

LLOYD'S Agent at the Dardanelles telegraphed as follows on October 28, 9.45 a.m.:—"An earthquake was felt here on Saturday. Very little damage has been done. Sigri Lighthouse, Mytilene, destroyed, also loss of life in island."

PROF. H. G. SEELEY finds that the pubic bone, which is of large size, does not enter into the acetabulum in the Plesiosaurian genus Colymbosaurus from the Oxford Clay. In that genus, the clavicle and inter-clavicle are developed as small separate ossifications, on the visceral aspect of the large scapular arch, and hence are not usually seen.

AT the recent meeting of the Congress of German Men of Science and Physicians at Heidelberg, Herr O. Ammon submitted to the Anthropological Section some interesting results of observations he had made in Baden. These observations related to 5000 soldiers. The tall men had generally long skulls, or skulls of medium length, whereas the short men had round skulls. Most of the round-skulled men came from the Black Forest; the long-skulled usually belonged to the valley of the Rhine, and were especially numerous in towns and in the neighbourhood of the castles of ancient families. From this fact Herr Ammon concluded that the round-skulled men had been the original inhabitants of the Rhine valley, that they had been driven from it by long-skulled invaders, and that the latter had established themselves near the settlements of their victorious leaders. Having shown that there is a certain relation between the height of the figure and the shape of the skull, Herr Ammon went on to indicate the relation between fair hair and blue eyes. No fewer than 80 per cent. of the men with blue eyes had fair hair. He found also that physical growth is generally quicker in the case of the brown-eyed than in that of the blue-eyed type.

AT the last meeting of the Andersonian Naturalists' Society of Glasgow, amongst the papers read was one by Mr. R. Turner Vice-President, on the Uredineæ and Ustilagineæ. He explained the relations of these microscopic Fungi to other plants, and their position in the vegetable kingdom. They are all parasitic upon some living plant, and consist of two essential elements—spores and mycelium. The spores are very diverse, the mycelium very similar. The same mycelium gives rise to several different kinds of spores, each of these being formerly regarded as a different genus. The production of cluster-cups and of the spermagonia, with their so-called spermatia, was described. It was shown that these spermatia have been by no means established as equivalent to pollen in function. As an example of heterœcism, the life-history of *Puccinea graminis* was traced: first, the æcidiospore stage on the barberry, then the rust on wheat, succeeded by mildew, and finally, the germination of the telentospores and the production again of æcidium on barberry. Many other instances of heterœcism were adduced, and some problems suggested for the consideration of members of the Society. The Ustilagineæ were then shortly referred to, and *Ustilago segetum*, the corn-smut, given as a familar example. The paper was illustrated by diagrams, specimens, and the sections shown under the microscope.

In a paper read before the Royal Danish Academy in February, M. Adam Paulsen gave some interesting particulars of observations made with the object of determining the height of the aurora. Two theodolites were used, the observing telescopes of which were replaced by short tubes having small holes at the eye ends and metallic cross wires at the other ends. Two of the stations were situated in the same magnetic meridian, on opposite banks of the fjord of Godthaab, at a distance apart of 5800·4 metres. The vertical circles of the two theodolites were placed in a common plane by means of observations of "blue fire" signals given at each station. Signals were also exchanged on the appearance of an aurora which it was thought possible to measure, so that simultaneous observations were secured, and it was previously agreed to direct the instruments to the base of the auroral arc. The observations at Godthaab gave heights for different auroræ ranging from 0·6 to 67·8 kilometres. A second series of observations with the same apparatus and methods was made in 1885 by MM. Garde and Eberlin at Nanortalik, near Cape Farewell, the base-line in this case being 1247·8 metres, and the values determined here were 1·6 to 15·5 kilometres. The results obtained by the staff of the Swedish International Expedition at Spitzbergen, with a base of 572·6 metres, range from 0·6 to 29·2 kilometres. These observations therefore lead to the conclusion that auroræ are by no means confined to the highest parts of our atmosphere, but that they occur almost indifferently at all altitudes. In support of this view, M. Paulsen gives accounts of several appearances of auroræ beneath the clouds and the summits of mountains. It is interesting to compare the new values with those given by previous observers. M. Flögel calculated the heights of several auroræ which appeared in the autumn of 1870, and concluded that only the very lowest parts of the aurora came at all within the limits of our atmosphere; he gave the actual limits as 150 to 500 kilometres. For an aurora on October 25, 1870, M. Reimann found a height of from 800 to 900 kilometres, and Nordenskiöld came to the conclusion that the mean height of auroræ was about 200 kilometres. On the other hand, Lemström has observed auroræ as low as 300 metres, and M. Hildebrandsson has seen auroræ in a completely clouded sky. Considering all the facts of the case, M. Paulsen inclines to believe that in the temperate zone, auroræ only appear in the higher layers of the atmosphere, whereas in the auroral zone, properly speaking, the phenomenon is generally produced in the lower layers.

In the new Quarterly Statement issued on behalf of the Palestine Exploration Fund, it is stated that Dr. Torrance, of the Scottish Mission, has undertaken to conduct a series of meteorological observations at Tiberias for the Fund. Should Dr. Torrance be able to carry out this undertaking, the observations will, with those made at Sarona, now being published by Mr. Glaisher, and those made by Dr. Chaplin at Jerusalem, and reported in the Quarterly Statement for 1883, place the Society after a few years in the possession of materials for a fairly complete account of the meteorology of Palestine. Tiberias is 682 feet below the level of the Mediterranean, and the Society hopes that, as no regular series of meteorological observations has ever been made in such a depressed situation, the results may be exceptionally interesting. As the neighbourhood of Jericho is becoming, to some extent, a place of residence for Europeans, the Society trusts that opportunity may before long present itself for meteorological observations there also.

Symons's Monthly Meteorological Magazine for October contains a climatological table for the British Empire for the year 1888, from which we extract the following interesting details. Adelaide had the highest shade temperature, 107°·5, on December 25, and was the driest station. Winnipeg had the lowest shade temperature, −46°·4, in February, the greatest mean daily range, 22°·5, and the lowest mean temperature, 32°·3. Colombo (Ceylon) had the highest mean temperature, 80°·9, and the greatest rainfall, 101·06 inches. Malta had the least rainfall, 13·75 inches, and was the least cloudy station. The highest temperature in the sun was registered at Calcutta, 165°·4; while London holds the unenviable position of the dampest and most cloudy station.

The *Annuaire de l'Observatoire Municipal de Moutsouris* for 1889 contains a considerable amount of meteorological information. Observations appear to have been made in connection with every branch of this science, and the tables, showing the results obtained in this and former years, are well constructed; the whole being discussed by M. Léon Descroix, from an agricultural and hygienic, as well as the meteorological, point of view. In addition to this, M. Albert Lévy contributes an elaborate series of analyses of air and water, samples of which had been gathered from various sources; and Dr. Miquel his eleventh memoir on the micro-organisms that are found in them.

Mr. James R. Gregory has issued a catalogue of his valuable collection of meteorites. The formation of this collection was begun nearly thirty years ago, and now Mr. Gregory finds that he can number upwards of 300 distinct "falls," "which," he says, "really places my collection among some of the largest in Europe as regards the number of falls, and in the average weight and excellence of the examples." As to arrangement, he has adopted, with a few variations, the principle of the new Catalogue of the British Museum collection in chief.

It has been generally supposed that the mango weevil infests the pulp of the fruit, but in a letter read at a recent meeting of the committee of the Agri-Horticultural Society of Madras, from Mr. C. I. Denton, forwarding specimens of mangoes, called by the Canarese the bee mango, he states that the peculiarity of the fruit is that the stone contains a bee existing on the kernel. Specimens of the insect were forwarded by the Madras Agri-Horticultural Society to Mr. Coates, of the Indian Museum, who identified them as *Cryptorhynchus mangifera*, the mango weevil, whose normal habitation is in the pulp of the fruit, and not within the stone. The fruit sent to the Society was carefully examined, and the pulp was, in every case, free from the insect, which was only discovered when the stones from which the pulp had been removed were broken open.

A third edition of Mr. Thomas Greenwood's "Free Public Libraries" is being prepared. Three years ago, when the first edition of this work was published, the total number of adoptions of the Acts during thirty-six years was only 133. At present there are 190.

A book on "The Birds of Essex," by Mr. Miller Christy, is to be published by subscription. It will form the second volume of the "Special Memoirs" of the Essex Field Club. The author has been collecting materials for this work for more than fifteen years, and he says that 271 species of birds are described as having been met with in Essex—a number which has been exceeded hitherto by very few other counties.

We have received the official report of the proceedings of the thirty-seventh meeting of the American Association for the

Advancement of Science, held at Cleveland in August 1888. The volume, we need scarcely say, contains addresses, reports, and papers of great interest. The Presidential address, delivered by Prof. S. P. Langley, is on the history of our present views about radiant energy.

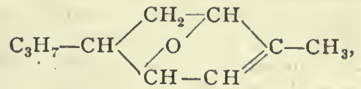
THE latest issue of the Proceedings of the Royal Society of Edinburgh (Session 1888–89) includes pp. 257–320 of vol. xvi. The following are the contents:—On the relation among the line, surface, and volume integrals, by Prof. Tait; the development of diarthrodial joints in birds and mammals, by David Hepburn; electrification of air by flame, by Sir Wm. Thomson; on the placentation of the halicore dugong, by Prof. Sir William Turner; on the geographical distribution of some tropical diseases, and their relation to physical phenomena, by R. W. Felkin (with 16 plates); quaternion note on a geometrical problem, by Prof. Tait; the solubility of carbonate of lime in fresh and sea water, by W. S. Anderson.

THE thirteenth part of Cassell's excellent "New Popular Educator" has been issued. It includes a good coloured plate representing the Rosegg glacier.

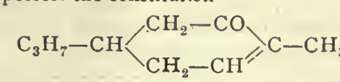
THE Glasgow and West of Scotland Technical College has issued its Calendar for the year 1889–90. We have received also the new Calendar of the University College of Wales, Aberystwith.

AN interesting paper on Japanese lacquer, read lately by Mr. R. Hitchcock before the Chemical Society of Washington, has been printed in the Proceedings of the United States National Museum. Japanese lacquer is the product of a tree, the *Rhus vernicifera*, D.C., which grows throughout the main island of Japan. It attains a large size, the trunks sometimes measuring a metre in diameter. It is said the tree will live for forty years, but only comparatively young trees are valued for the production of lacquer. Having yielded for several years they are cut down, the lacquer extracted from the branches, and young trees take their places. Having given an account of the chemical composition of lacquer, and described the uses to which it is applied, Mr. Hitchcock urges that it should receive more attention than has hitherto been devoted to it by manufacturers in America. "It gives a surface to wood," he says, "much harder than our best copal varnish, without brittleness. It takes a polish not to be excelled, which lasts for centuries, as we may see in the old treasures of Japan. It is proof against boiling water, alcohol, and, indeed, it seems to be insoluble in every agent known. It is the best possible application for laboratory tables. I have a set of photographer's developing trays that have been in use for more than a year, and I find them excellent and cheap. In Japan it is used for many household articles." Unfortunately, lacquer poisoning from the fresh material is a serious danger. According to Rein, the poison is a volatile acid, and Mr. Hitchcock suggests that it might be removed by a heat that would leave the lacquer uninjured.

AN isomer of camphor, $C_{10}H_{16}O$, has been prepared by Drs Wallach and Otto in the chemical laboratory of the University of Bonn (*Liebig's Annalen*). This new substance is a liquid, to which the name pinol is provisionally given, possessing a very strong camphor-like odour. It is obtained by the action of hydrochloric acid upon a well-cooled mixture of turpentine oil, glacial acetic acid, and ethyl nitrite. The hydrochloric acid is gradually added in the form of a concentrated solution, and its addition is followed by the separation of crystals of the nitroso-chloride of pinene, one of the terpenes, and the formation in the solution of pinol, the new camphor. The whole is allowed to stand for about twelve hours at a low temperature to complete the precipitation of the first-named body, after which the crystals are filtered off, and the filtrate is subsequently distilled in steam. A rapid evolution of gas occurs at the commencement of the distillation, after which the pinol is quietly conveyed over in the steam. The distillate separates into two distinct layers, and the aqueous layer is readily separated by means of a funnel. The dried distillate is then freed from acetic ether by fractional distillation, and the higher boiling portion again distilled in steam. This redistilled product is similarly separated from water, dried, and finally itself subjected to fractional distillation: when the principal fraction, consisting of pinol with a small quantity of impurity, passes over between 182° and 188° C. The liquid thus obtained is found to possess in a very marked degree the odour of camphor, and it can be freed from the last traces of impurity by taking advantage of the action of bromine upon it. Bromine yields with pinol a beautifully crystalline dibromide, $C_{10}H_{16}OBr_2$. On diluting the distillate, therefore, with twice its volume of glacial acetic acid, and running in a thin stream or drops of liquid bromine, the colour of the latter rapidly disappears, and, on evaporating, splendid rhombic crystals of this dibromide are obtained. In order to recover the pinol in a pure state from the recrystallized dibromide, about a hundred grams of the latter are boiled with excess of alcoholic potash for a whole day, and the product distilled in steam, separated from water, dried with solid potash, and repeatedly fractionally distilled. Finally, pure pinol is obtained, boiling constantly at 183–84°. Analyses of this product conclusively point to the formula $C_{10}H_{16}O$, the same as that of ordinary camphor. Its constitution is proved to differ, however, from the latter body by the nature of its oxidation products. Both potassium permanganate and dilute nitric acid oxidize it to carbonic anhydride, oxalic acid, and terebic acid, $C_7H_{10}O_4$. The only possible constitution compatible with these facts is



while ordinary camphor is generally assumed on Kekulé's authority to possess the constitution



An extremely interesting fact about pinol is that its nitroso-chloride readily reacts with β-naphthylamine to form a base of the formula $C_{20}H_{24}N_2O_2$, isomeric with quinine. This is the first base of this empirical formula which has yet been artificially prepared. Solutions of both the base and its salts present similar fluorescent phenomena to those of quinine and its salts.

THE additions to the Zoological Society's Gardens during the past week include a Gaur (*Bos gaurus* ♂) from Pehang, Malay Peninsula, presented by Sir Cecil C. Smith, K.C.M.G.; three Blue-crowned Hanging Parrakeets (*Loriculus galgalus*) from Malacca, presented by Mr. A. Baker; a Short-tailed Capromys (*Capromys brachyurus*) from Cuba; two Reed Buntings (*Emberiza schœniclus*), British, purchased; three Dingo Dogs (*Canis dingo* ♂ ♂ ♀), a White Goshawk (*Astur novæ-hollandiæ*), a Berigora Hawk (*Hieracidea berigora*), a Brush Turkey (*Talegalla lathami* ♀), an Australian Thicknee (*Œdicnemus grallarius*) from Australia, received in exchange.

OUR ASTRONOMICAL COLUMN.

THE NATAL OBSERVATORY.—The Report of this Observatory for 1888, which has recently come to hand, is a somewhat meagre one, and is chiefly occupied with the routine daily meteorological observations. The small record of astronomical work achieved may perhaps be explained by the circumstance that the Superintendent, Mr. Nevill, has recently been appointed Government Chemist and Official Assayer for Natal, that a laboratory was erected for him in the early part of the year, and that he has already commenced his official duties in his new capacity.

Of direct astronomical work the Report only records the routine work in connection with the maintenance of the system of colonial time signals; a number of observations of the zenith distances of northern stars and circumpolars both above and below the Pole, for the comparison of declinations as observed at Observatories on either side of the equator; and some progress as having been made in the observation of pairs of equi-zenith distance stars for the determination of the latitude of the Observatory. The various computations undertaken at the Observatory have been pushed forward much more zealously. These embrace the comparison of the Greenwich lunar observations for the decade 1878–87 with Hansen's lunar tables; the reduction of Mr. Campbell's observations of the lunar crater Murchison A, made at the Arkley Observatory in the years 1882–84; and the reduction of the third year's tidal observations at Durban.

THE SPECTRUM OF R ANDROMEDÆ.—Mr. Espin, who has recently discovered bright lines in the spectra of several long-period variables of Secchi's third type, has added another to the list; R Andromedæ, at the maximum just passed, showing a number of bright lines, F being very bright, so bright as to appear to project beyond the spectrum. The spectrum of the star had manifestly undergone a great change from the time when Dunér made the very thorough study of it which he has recorded in his work on "Les Étoiles à Spectres de la Troisième Classe." Five of the seven variables included in Mr. Lockyer's Species 10 of this type have now shown bright lines at maximum, whilst Gore's Nova Orionis, which should certainly be included in the same species, would make a sixth. The two stars in which bright lines have not yet been observed are R Leonis Minoris and α Herculis.

COMET 1889 *d* (BROOKS, JULY 6).—The following ephemeris is in continuation of that given in NATURE for October 3 (p. 550):—

Ephemeris for Berlin Midnight.

1889.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
Nov. 1	23 41 40	2 32·2 S.	0·2977	0·0625	1·8
5	23 42 56	2 3·6	0·2988	0·0754	1·7
9	53 44 39	1 33·1	0·3001	0·0888	1·6
13	23 46 49	1 0·8	0·3015	0·1025	1·5
17	23 49 25	0 27·0 S.	0·3030	0·1163	1·4
21	23 52 25	0 8·4 N.	0·3046	0·1303	1·3
25	23 55 49	0 45·2	0·3063	0·1445	1·2
29	23 59 34	1 23·3 N.	0·3082	0·1587	1 1

The brightness at discovery is taken as unity.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 NOVEMBER 3–9.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on November 3

Sun rises, 7h. 0m.; souths, 11h. 43m. 40·4s.; daily increase of southing, 0·5s.; sets, 16h. 28m.: right asc. on meridian, 14h. 35·4m.; decl. 15° 13′ S. Sidereal Time at Sunset, 19h. 21m.

Moon (Full on November 7, 16h.) rises, 15h. 30m.; souths, 21h. 1m.; sets, 2h. 45m.*: right asc. on meridian, 23h. 54·5m.; decl. 6° 7′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian h. m.	Declination on meridian ° ′
Mercury..	5 8	10 37	16 6	13 28·3	6 53 S.
Venus ...	4 29	10 9	15 49	13 0·0	4 37 S.
Mars ...	2 35	8 54	15 13	11 45·3	3 5 N.
Jupiter ...	11 38	15 31	19 24	18 23·6	23 27 S.
Saturn ...	0 22	7 28	14 34	10 19·5	11 53 N.
Uranus ...	5 16	10 36	15 56	13 28·0	8 37 S.
Neptune..	17 30*	1 18	9 6	4 8·4	19 15 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Saturn, November 3.—Outer major axis of outer ring = 39″·3; outer minor axis of outer ring = 5″·8: southern surface visible.

Meteor-Showers.

	R.A.	Decl.	
Near γ Camelopardalis...	55°	71° N.	Swift.
,, the *Pleiades* ...	60	20 N.	The *Taurids.*
,, θ Ursæ Majoris ...	143	50 N.	Very swift.
From Lacerta...	346	52 N.	Rather slow.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′			h. m.	
U Cephei	0 52·5	81 17 N.	Nov.	4,	1 23	*m*
			,,	9,	1 3	*m*
R Canis Majoris	7 14·5	16 11 N.	,,	6,	17 5	*m*
			,,	7,	20 20	*m*
S Cancri	8 37·6	19 26 N.	,,	3,	21 22	*m*
U Ophiuchi	17 10·9	1 20 N.	,,	5,	18 29	*m*
R Scuti	18 41·6	5 50 S.	,,	8,		*m*
U Aquilæ	19 23·4	7 16 S.	,,	9,	21 0	*M*
χ Cygni	19 46·3	32 38 N.	,,	6,		*m*
T Vulpeculæ	20 46·8	27 50 N.	,,	9,	21 0	*m*
Y Cygni	20 47·6	34 14 N.	,,	4,	15 40	*m*
			,,	7,	15 35	*m*
δ Cephei	22 25·0	57 51 N.	,,	8,	23 0	*M*

M signifies maximum; *m* minimum.

SEISMOLOGICAL WORK IN JAPAN.[1]

THE seismological work which has been accomplished in Japan is to a great extent described in fourteen small volumes published by a Society which was organized in 1880 to study phenomena connected with earthquakes and volcanoes. This Society is called the Seismological Society of Japan. An epitome of a portion of this work is to be found in nine Reports on the volcanic phenomena of Japan issued by this Association. A glance at the first few volumes published by the Seismological Society shows that the attention of its members was directed towards seismometry. For several years attempts were made to record earthquakes by using the old types of earthquake instruments, such as columns balanced on end, bowls or tubes filled with liquid, pendulums with pencils or pointers writing on paper or smoked glass. The records obtained from instruments of this order were, however, gradually recognized as being too indefinite; the instruments indicated that shakings had taken place, but they failed to measure them. All investigators recognized that to measure the movement of the earth it was necessary, while the movement was going on, to obtain a steady point or platform relatively to which the motion might be measured. By the patient labours of investigators in Japan, which have extended over many years, this has been accomplished, and we now have pendulums and other forms of instruments which for small displacements are in neutral equilibrium, so that when the frames carrying these instruments are shaken back and forth or up and down there are certain portions of them which remain at rest. From these steady points pointers project which write the movements or magnified representations of these movements upon suitably prepared surfaces.

From the simple pendulum and style, tracing its movements in sand, and costing but a few pence, elaborate instruments, embracing many new mechanical contrivances, and writing their movements with delicate siphons on continuously running bands of paper, have gradually been evolved. With the assistance of these instruments many thousands of diagrams, each of which represents in absolute measures the back and forth motions of the ground during an earthquake, have been obtained, and we now know the true nature of earthquake movement. We have learnt that, in many earthquakes which are quite perceptible and sometimes even alarming, the amplitude of motion may not exceed a millimetre, while if it reached 25 millimetres, or an inch, we might expect cities to be ruined.

The results which have flowed from a study of these diagrams are numerous and interesting. We now know that the direction of movement in any given earthquake is continually varying. At one moment a point on the surface of the earth may be moving north and south, and the next moment it may be moving east and west, while at other times it may be following a path too intricate to be easily described.

More interesting observations relate to the period and amplitude of the earth's motion, from which may be calculated the destructive power, which depends partly on the maximum velocity and partly on the suddenness of movement. Some earthquakes commence with preliminary tremors, which have been recorded with a frequency of eight or ten waves per second.

The back and forth movements of considerable amplitude which constitute the shock or shocks in an earthquake usually have a period of one or two seconds, while the ordinary back

[1] A Paper, by Prof. John Milne, of the Imperial University of Japan, Tokio, read at the British Association.

and forth movements, constituting a greater part of the shaking that is sensible, have usually a period of from three to five per second. At the end of a disturbance the wave-period is almost always very much greater than it is at the commencement or middle of a disturbance. Quite recently an earthquake was recorded in Japan, having a period of from six to eight seconds.

Observations like this are undoubtedly valuable from a scientific standpoint, but many observations are of practical importance. For example, we now know that a seismic survey can be made of any given piece of property, and as the result of such a survey it may be found that buildings erected on one side of the given area may suffer very much more than those upon the other side. Again, we know that, because in severe earthquakes the motion at the bottom of a comparatively shallow pit is very much less than it is upon the surface, buildings may be partially cut off from earthquake motion by giving them proper foundations.

In addition to the theoretical and practical results which have flowed from the study of earthquake diagrams, mechanical science has gained something from the new types of machines that have been evolved. Now we know how to make pendulums astatic. New combinations in clockwork have been invented, new governors for machinery designed, some of which have already proved themselves useful for other purposes than earthquake machinery. One machine, which has been the outcome of seismological work in Japan, and which promises to be of practical value outside the domain of seismology, is an instrument which records the vibrations in a railway train. With diagrams of these vibrations before us, we are enabled to time a train between stations, to see when it went quickly and when it went slowly, to note the duration of stoppages, to detect irregularities on a line, as, for instance, those which may occur at crossings and points, those due to a want of ballast, variations in gauge, imperfections in bridges, &c.

Seismometrical observations have not alone been confined to the observation of earthquakes proper, but observations have been made upon disturbances produced by explosions of substances like dynamite and gunpowder, the falling of heavy weights, and the moving of trains, &c. The records obtained from these experiments have perhaps taught us more about the nature of earth vibrations than we have obtained from the observation of actual earthquakes. So far as surface disturbances in superficial soil are concerned, we now know that the phenomena they present are anything but what we might anticipate as likely to occur in a theoretically elastic material.

An extremely practical subject which has received attention in Japan has been observations and experiments upon the effects produced by earthquakes upon buildings; an account of them —many of which have been successfully put into practice by builders—is now being published as the fourteenth volume of the Seismological Society's Transactions. As this particular subject is of such vital importance to the Government of Japan, who are continually erecting European structures, it is at the present time being discussed by a Committee of engineers, architects, and others, summoned for the purpose by the late Viscount Mori, Minister of Education.

The Imperial Government of Japan, by establishing in the Meteorological Department an Earthquake Bureau, and in the Imperial University a Chair of Seismology, have given an impetus to seismological investigation in general. In several parts of the country seismographs have been established, and, at between 600 and 700 stations, records are kept of all disturbances which are felt. From these records we are now able to study the distribution of seismic activity, both with regard to space and time. For instance, we now know that the greater number of shocks originate on or near the eastern coast; we know that there are many "centrums," from some of which weak, and from others strong, shocks originate; that, on the average, we feel in Japan at least two shocks per day.

Inasmuch as earthquake disturbances are relatively superficial, we may consider the area of disturbance as a very fair estimate of seismic effort. In 1885 the land area shaken was about 660,000 square miles, and in 1886 it was about 562,000 square miles.

Here we have the commencement of a series of interesting figures which may, perhaps, be related to a heat-gradient—to the fluctuations in the flow of the Black Stream, or to something not yet thought about.

Hitherto, when studying earthquakes in relation to meteorological changes, the position of the moon, the seasons, &c., we have been compelled to take very imperfect catalogues of shocks which have originated from "centrums" as independent of each other as most volcanoes are of each other. Now we are getting material which will enable us to study a group of earthquakes which have come from a given origin. Disturbances in the ocean have not been overlooked, and the waves which Japan has sent to America, and those which America has returned, have been carefully investigated, and average depths of the ocean along several lines have been determined. In all instances it appears that the depths calculated from the transmission of a sea-wave are a little less than the depths obtained by averaging the soundings. Does this mean that there is an incompleteness in the formulæ which have been used? or does it mean that sailors have allowed their line to run a little after striking bottom?

Other investigations which have been made relate to the effects produced by earthquakes upon the lower animals; and one investigator, Prof. Sekiya, at one time kept pheasants purposely to observe their behaviour at the time of an earthquake. A conclusion arrived at is that pheasants, geese, horses, and other animals often show decided symptoms of alarm a few seconds before the occurrence of a severe shaking. The reason of this probably is that they are more sensitive to preliminary tremors than human beings.

The relationship between volcanic phenomena, earth currents and magnetism, and earth disturbances, has not been unnoticed, while mathematicians and physicists have had new problems suggested to them respecting the determination of earthquake origins, the depth of "centrums," the force required to cause destruction like the shattering and overturning of structures, the propagation of surface waves, &c.

The observations of late years respecting the destruction of submarine cables have led Mr. Forster, of Zante, to the opinion that certain earthquakes are the immediate result of submarine landslips, and suggested to Japanese observers that something might be learnt by periodical soundings made along the Japanese shores. Volcanoes have not been overlooked, and many new facts have been obtained for vulcanologists. For instance, we now know that many volcanoes have a definite curvature dependent upon the density and strength of the materials of which they are built, and given any two of these three quantities—curvature, density, and strength—we may determine the third; thus, as pointed out by Mr. Becker, of the United States Geological Survey, may not the shape of lunar volcanoes, with an assumption as to the density of the material of which they are composed, lead to an opinion as to the materials out of which they are made?

About the extremely minute movements called earth tremors, which are probably in all places and at all times to be observed, much has been done. For three or four years, by a specially-contrived instrument, these have been recorded automatically. The investigation of these records has led to the conclusion that earth tremors are closely connected with wind. When a heavy wind is blowing, tremors are usually strongly marked, but the more curious result is that they are often very marked in calm weather. An inspection of the tri-daily weather maps published in Japan shows that on these occasions a heavy wind is blowing against high mountains 60 to 200 miles distant. From this it appears that earth tremors outrace storms inland, much in the same way that small waves outrace storms upon the ocean. Insomuch as earth tremors accompany heavy barometrical gradients, and these are related to the outpouring of fire-damp in our mines, it would appear a legitimate investigation to study the behaviour of a tromometer, say in the Newcastle area, in relation to the escape of underground gas. Hitherto I believe that investigators in Great Britain have been observing seismometers rather than tromometers.

With these few remarks respecting the general nature of investigations which have been made and are yet going on in Japan, I will enumerate a few phenomena which require explanation, and suggest a few investigations which have yet to be undertaken.

Large earthquakes are usually preceded by a series of short-period vibrations. These vibrations have an amplitude of about one-tenth of a millimetre, and six to ten of them occur per second. With a seismograph giving great multiplication, it is probable that still smaller and more rapidly recurring waves may be recorded. These hitherto unseen portions of an earthquake may be the cause of the sound-phenomena of earthquakes, and the movements which, although not felt by human beings, alarm the lower animals. Why are the larger movements of an earthquake preceded by tremors of this description?

The rate at which earthquake motion is propagated is sometimes very high. From Toronto to Ontario in the Charleston earthquake of 1886 the velocity was over 15,000 feet per second, whilst at the destruction of Flood Rock, in 1885, velocities of 20,000 feet per second were observed.

As was suggested by Sir William Thomson, observations like these may mean that the rigidity of the Earth is greater than that of surface rocks. If it is so, then, as Sir William suggested, extended observations may lead to the determination of these rigidities. In connection with this, it must be remarked, that, both for artificial as well as for natural disturbances, the velocity of transmission varies with the intensity of the initial disturbance, the nature of the medium, and it becomes less as a disturbance radiates. General Abbot, however, in one instance noted an increase in velocity as a disturbance radiated.

What is perhaps closely connected with the above, or what at least is analogous, is the fact that at a given station the wave-period becomes longer as a disturbance dies out, and it also becomes longer as a disturbance radiates. One inference to be drawn from this may be that long-period earthquakes originate at a distance, a wave flattening out as it radiates, pretty much as it does in the ocean; but Sir William Thomson has suggested that a long-period disturbance may be related to the dimensions of the focal cavity. Recently, in Tokio, an earthquake having a period of about eight seconds was observed. For seismographs to record this, they must have been tipped from side to side.

Another point of interest is that for *small* displacements period increases with amplitude, but after a certain amplitude is reached the period is either constant or only increases very slowly. This observation apparently harmonizes earth motions with those of ideally elastic bodies.

Another set of interesting observations is the relationship between normal and transverse movements. At a short distance from an origin the normal movement distinctly outraces the transverse motion, but when the amplitude of the normal motion has been decreased until it practically equals that of the transverse motion the separation between the movements is *nil*. A curious feature, especially in normal movements, is the fact that near an origin the movement inwards or towards the source of the disturbance is greater than it is outwards; further, as a normal wave radiates it may be observed to gradually break up into two waves, in consequence of which a diagram taken at one station may be very different from one taken at another.

In conclusion, I will point out a few observations which, on account of the expense they involve, the difficulty of obtaining observers, &c., have not, or at least only partially, yet been undertaken:—

1. *Velocity of Earthquake Propagation.*

The importance of determining the velocity of earthquake propagation has already been noted, and it has been shown that on account of the difference in the aspect of diagrams at neighbouring stations it cannot be done on a small area. The Imperial Telegraph Department of Japan is at the present moment giving its assistance in this matter, but as so much depends upon telegraph operators who have duties to attend to, a number of specially constructed timepieces are required.

2. *A Gravity Observatory.*

Many years ago Sir William Thomson suggested the importance of an observatory to determine whether there are changes in the value of G. In Japan we have a country where superficial and probably subterranean and suboceanic changes are taking place very rapidly. Last year the greater portion of a mountain was blown away, and an area measuring 12 miles by 10 miles was, in ten minutes, or less, buried from 30 to 100 feet beneath a stream of earth and rock. What is going on beneath our volcanoes we do not know, but every now and then they pour out volumes of solid matter. Along the coast we have a sharp and deep depression, perhaps the deepest on the face of the globe. Do submarine landslips take place along this coast, as they most certainly have done in other parts of the world?

Lastly, may there not be an apparent change in the value of G, dependent upon the time at which the observations have been made? At certain seasons tremor storms are very marked, and may not their minute movements have a cumulative effect upon the small swings of pendulums used in gravity determinations. Pendulum observations of the ordinary kind have been made in many parts of Japan, from the summit of Fujiyama to the Bonin Islands, but neither in Japan nor in any other portion of the world—so far as the writer is aware—has a pendulum been swung at a given point for a considerable period of time.

3. *Observations on Submarine Changes.*

Many of the Japanese earthquakes originate near the deep submarine depression which has been spoken about. If any of these are due to suboceanic land slides or sinkings, as have been observed in the Mediterranean and in the Atlantic, such changes might be noted by periodical soundings, and perhaps even by the records of tide-gauges.

4. *Magnetic Observations.*

Dr. Edmund Naumann called attention to the fact that near certain Japanese volcanoes there have been abnormal changes in declination. The volcanic rocks of Japan are exceedingly magnetic, and they are of enormous extent. Many of the rocks in Fujiyama will deflect an ordinary compass needle through 180°. Now, as these rocks are sometimes hot and sometimes cold, whilst at the time of an eruption, and possibly at other times, there are subterranean shiftings in the positions of these magnetic masses, could not these changes be noted by establishing a magnetic observatory on the side, say, of a recent volcano like Fujiyama?

5. *Bending of the Earth Crust due to Tidal Load.*

Some years ago, in conjunction with Mr. John Stoddart, Manager of the Takashima Colliery, the workings of which extend a considerable distance beneath the Pacific Ocean, the writer, by means of a simple apparatus, endeavoured to measure any movement of the roof of the mine which might be occasioned by the rise and fall in the tide. Unfortunately, the apparatus together with other instruments were lost by a complete subsidence in one portion of the workings, and these observations, if they are of any value, have to be recommenced.

6. *Tromometric Observations.*

A continuous automatic observation of earth tremors has hitherto only been made in Tokio. Might not these observations be continued in a coal-mining region to determine whether these minute earth movements, which are certainly connected with barometrical changes, hold any relation to the outflow of fire-damp.

7. *Earth Currents.*

Have earth currents any relationship to earth tremors and to earthquakes? Earth currents are produced when the ground is shaken by an explosion of dynamite, but this might be due to the increase or diminution of pressure in the earth plates causing changes in chemical activity. Have earth currents been observed in the vicinity of an active volcano, or in relation to some large earth fracture?

8. *Earth Oscillations.*

In Japan the borings of marine shells, 10 or 12 feet above high-water mark, in very soft rock which easily disintegrates, shows that there has been a rapid movement in the earth's crust relatively to sea-level. Is it likely that this could be measured, and the axis of the movement be determined, by repeating, at intervals of twelve months, the levelling of two lines running as nearly as possible at right angles to each other? It has been suggested that, if the movement is rapid, say 1 inch per year in a large bay like that of Tokio when the rise and fall of the tide is small, the isochronous observation of records obtained under approximately similar conditions from a series of tide-gauges, the level at each gauge relative to some fixed point on the neighbouring rocks being known, might furnish data which would be of value in the measuring of earth oscillations.

These, then, are a few suggestions respecting work which might perhaps be better carried out in Japan than in most other countries. They are laid before this meeting for the purpose of obtaining an opinion as to how far they may be regarded as legitimate subjects for investigation; and if the members of the meeting will freely criticize them, or suggest other lines of research, a benefit will be conferred upon workers in Japan, and on all who are interested in earth physics.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Smith's Prizes have been adjudged as follows:—To H. F. Baker, B.A., of St. John's College, for his essay entitled "The Complete System of 148 Concomitants of Three Ternary Quadrics, in terms of which all others are expressible as Rational Integral Algebraic Functions, with an Account of the Present Theory of Three such Forms." To J. H. Michell, B.A., of Trinity College, for his essay entitled "The Vibrations of Curved Rods and Shells." The adjudicators place the two names in alphabetical order, not desiring to assign precedence to one essay over the other. Mr. Baker and Mr. Michell were bracketed Senior Wranglers in 1887.

SCIENTIFIC SERIALS.

Revue d'Anthropologie, troisième série, tome iv., cinquième fasc. (Paris, 1889).—A chart of the colour of the eyes and hair in France, by M. Topinard. The author explains at length the methods he has adopted in elaborating the great mass of materials supplied him by the 2000 collaborators, at home and abroad, who responded to his appeal when, in 1886, at the suggestion of Dr. Beddoe, he undertook to examine the relations between the colour of the hair and the eyes among different peoples. In this chart of the general distribution of the blonde and the brunette types in the several departments of France, the variations between the extremes of these elements are clearly indicated by various shades from white to black. We are thus able at a glance to observe that while France generally admits of being divided into two great zones, the one occupying the north-east and the other the south-west of the French territories, each includes one or more departments in which an opposite type crops up. In most instances this anomaly may be accounted for by the early history of the invasions and foreign settlements to which France was subjected before its various parts were welded together. Thus it appears that the blonde races entered both by land from the Low Countries on the east, and by sea from Belgium, the Franks and Burgundians having invaded the country on one side, while Franks, Saxons, Normans, and Britons advanced on the opposite side. Similarly, men of the brunette type entered France on one hand from the Ligurian coasts of the Mediterranean, and on the other from Iberia. A curious fact is mentioned by M. Topinard—that, while the blonde races followed the left bank of the Rhone valley, the dark races advanced along the Bay of Biscay as far as the Vendée, where the two came into contact, the latter being soon repulsed, and forced to follow the course of the Loire as far as Blois. By a comparison f the various tables it appears that some departments show a predominance of one colour in relation to the eyes, and an opposite one in regard to the hair. There is, however, only one department which can be classed as being blonde in relation to the hair and brunette in regard to the eyes. This, and various other anomalies, presenting great interest from an ethnological point of view, have been considered by M. Topinard with his usual ability, and although he treats only of the relative distribution of colour in the eyes and hair among the French people, his paper is a model for similar investigations, and worthy the gratitude of all ethnological inquirers.—Kashgaria, and the passes of Tian-Shan, by Dr. N. Seeland. In this concluding number of his contributions to our scanty knowledge of this part of Turkestan, the writer describes his visit to the city of Aksou, lying on a plain 3500 feet above the level of the sea, and not far from the River Aksou-Daria.—The Stone Age in Italy, by M. P. Castelfranco. This is a concise, yet comprehensive, description of the human and other osseous remains, and of the various objects found in the Palæolithic stations of Italy in recent years, giving all necessary details concerning the times of discovery, and the character of the several caves and stations where they occurred. As yet there is no evidence of the existence of man in Italy in the Tertiary age; his appearance there being apparently not earlier than the close of the Quaternary, and contemporaneous with *Ursus spelæus*. The period of the Cave-dwellers must, however, have coexisted with certain phases of civilization, since, in Liguria more especially, jade arms are found blended with bone and stone weapons and other implements in the graves of these Italian Troglodytes, whose remains closely resemble those of the Cro Magnon men. Thus far, the finds in Italy, which the author describes at great length, do not admit of being referred with any exactitude to the successive periods of the Palæolithic Age recognized elsewhere. The value of M. Castelfranco's treatise is increased by an appendix of bibliographic notices, which will be found of great use to the English reader.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 21.—M. Des Cloizeaux, President, in the chair.—Researches on the relations existing between the physical characters of plants and the proportion of elements of fertility in the soil, by M. G. Ville. The composition of the soil influences colour, size, weight, general aspect, the amount of carotine, and that of chlorophyll. In plants with nitrogen predominating (hemp, wheat, &c.), least carotine is found when a manure without nitrogen has been used; in those with potash predominating (potato, vine), when potash has been suppressed. The variations in chlorophyll correspond to those of carotine. For each plant there is a time when the contrasts of colour reach their maximum. M. Ville shows, in a diagram, how a hemp plant varied with different manures.—Observations of Barnard's comet (September 2, 1888) 1889, I., made with the 0·38 m. equatorial of Bordeaux Observatory, by MM. G. Rayet and Courty, by M. G. Rayet.—On a method of measuring the flexure of a mural circle, independently of the telescope, by M. Périgaud. A rigid rod, the length of the diameter, is attached to the axis, so as to be able to turn round it and be fixed in any position. Divisions traced on it, near the ends, are examined through two microscopes 180°, apart. After one reading, the circle is turned 180°, and a second reading taken.—On the invariants of a linear and homogeneous differential equation, by M. Mittag-Leffler.—On surfaces of which the ds^2 is reducible in several ways to Liouville's form, by M. G. Kœnigs.—On the simultaneous synthesis of water and hydrochloric acid, by MM. P. Hautefeuille and J. Margottet. Mixtures formed by adding chlorine to the gaseous elements of water, or oxygen to the elements of hydrochloric acid, were exposed to the electric spark. If the volume of chlorine is more than half the hydrogen, the ratio of the numbers of equivalents of water and hydrochloric acid formed is always less than unity, and it diminishes rapidly with increase of the chlorine; when it is double the hydrogen, the water ceases to be appreciable. When oxygen is added to the elements of hydrochloric acid, the above ratio is always less than unity, but varies only between narrow limits, in increasing the ratio of volumes of O and H from $\frac{1}{4}$ to 3.—On the existence of sulphate of phosphonium, by M. A. Besson. Dry gaseous phosphoretted hydrogen passed into sulphuric acid kept at 20° to 25° below zero, is largely absorbed, the liquid becoming syrupy. The product is then pretty stable, and may be kept at a few degrees below zero. On decanting, a white very deliquescent crystalline mass is found, which seems to be sulphate of phosphonium. Thrown into water at ordinary temperature, it is decomposed with a crackling noise, liberating phosphoretted hydrogen without reduction of sulphuric acid. The white mass, as it rises to the ordinary temperature, decomposes with reduction of sulphuric acid and oxidation of phosphorus.—On the action of ammoniacal sulphate of copper on sorbite and on mannite (a reply), by M. Guignet.—On the *rôle* of ammonia in the nutrition of the higher plants, by M. A. Müntz. He finds, by experiment with bean, maize, hemp, &c., that such plants can directly absorb ammoniacal nitrogen by their roots; the nitrification of ammonical manures not being indispensable to their utilization.—On the mucous canals of Cyclopterides, by M. F. Guitel. There are three systems of these, two maxillo-opercular (one on each side), and one median, with symmetrical halves. Each half of the latter system (in *Liparis*) has eleven orifices, and each maxillo-opercular system seven, making thirty-six. Full details are given.—New contributions to the geological study of the Lower Alps, by M. W. Kilian. In the Upper Jurassic epoch there seem to have been a series of coralligenous reefs in the position of the mountains of Ubaye; and a shallow part of the Oolitic sea is here indicated. The eastern limit hitherto assigned to the Lower Cretaceous sea should be put back considerably.—On a new way of preparing oxamide and oxamic acid, by M. E. Mathieu-Plessy. Oxalate of ammonium is introduced into fused nitrate of ammonia, and the whole kept four hours between 170° and 175°.—Attempt to produce an iodide of nitrogen photometer, by M. G. Lion. This is based on comparison of the volumes of nitrogen produced in equal times, by the light examined, and by a light standard.—Volumes on the life and works of D'Alembert (Bertrand), and on the flight of birds (Marey), &c., were presented.

BERLIN.

Meteorological Society, October 8.—Dr. Vettin, President, in the chair.—Prof. Assmann spoke of his meteorological experiences on the Sentis (Canton Appenzell). In order to be able to reply to the objections which have been raised in many quarters against his aspiration-thermometer, he submitted this instrument, in the form which it has now assumed, to a testing under the most unfavourable conditions. The instrument ought to record the temperature of the surrounding air alone even when exposed to the most intense solar radiation, and not be in any way affected by the latter. In order to determine whether it conforms to the above requirement or not, he lived for four weeks on the Sentis, and found, as the outcome of several thousand experiments, that the instrument thoroughly acts up to what is required of it, when its form, as originally exhibited to the Society, is modified so that a constant current of air is drawn through the metallic tube which surrounds the thermometer by means of an arrangement of clock-work. This clock-work is attached to the upper end of the tube, and drives a fan with considerable velocity, thus forcing the air out of the tube at the top and drawing it up from the lower portion of the tube; by this means a rapid constant current of air is kept streaming over the bulb of the thermometer. He had previously satisfied himself by direct experiments with hot water that the indications of the thermometer are not in any way affected, even when the temperature of the metal tube which surrounds it is raised to 20° C. above that of the surrounding air. On the Sentis, however, the direct solar radiation never raised the temperature of the metal tube by more than 3° C. The solar radiation, measured by means of a blackened thermometer *in vacuo*, was 33° C., while at the same time the temperature of the air was 3° C. Simultaneously with the speaker's own measurements of temperature on the Sentis, Dr. Siegfeld, in Munich, made similar measurements with a similar instrument in a balloon floating at a height equal to that of the Sentis peak; and further, at the same time, a corresponding set of experiments were carried on in a balloon at Berlin. It is his intention to publish an account of these interesting experiments in some scientific treatise which will appear shortly. Dr. Assmann further described the arrangement of the meteorological station on the Sentis, his testing of the instruments which it contains, and a prolonged series of very interesting observations on thunderstorms, which were of daily occurrence: these storms were remarkable for the suddenness of their development, and the very striking cloud-formations by which they were accompanied, the latter being recorded photographically. One of his most striking experiences was of a fall of hail which lasted for an hour and a half, the hail falling from a cloud which was not more than 350 metres above him. He concluded his address by a very full description of a series of observations on cases of St. Elmo's fire which were characterized by acoustical rather than optical phenomena.—Lieutenant Gross gave a short account of the balloon journey which he made in order to determine, simultaneously with the observations on the Sentis, the temperature of the air in the higher regions above Berlin. The balloon reached an elevation of 3600 metres, at which height the temperature recorded was − 7° C., the temperature at the earth's surface being at the same time + 25° C.—Dr. von Dankelmann exhibited a series of curves of temperature and air-pressure which had been registered in Cameroon by means of self-recording instruments.

Diary of Societies.

LONDON.

FRIDAY, NOVEMBER 1.

PHYSICAL SOCIETY, at 5.—On Electrifications due to the Contact of Gases with Liquids: J. Enright.—On a New Electric Radiation Meter: W. G. Gregory.—On a Physical Basis for the Theory of Errors: Dr. C. V. Burton.

GEOLOGISTS' ASSOCIATION, at 8.—On Metal Mining: Upfield Green.

SATURDAY, NOVEMBER 2.

ESSEX FIELD CLUB, at 7.—Exhibition and Remarks thereon.—Delegate's Report of the British Association Conference of Local Societies at Newcastle-on-Tyne: William White.—On Collecting Diptera; with Remarks on the Diptera of Epping Forest: E. Brunetti.—Notes on the Pleistocene Deposits at Felstead, Essex: J. French.

MONDAY, NOVEMBER 4.

ROYAL INSTITUTION, at 5.—General Monthly Meeting.

TUESDAY, NOVEMBER 5.

ZOOLOGICAL SOCIETY, at 8.30.—On New Indian Lepidoptera, chiefly Heterocera: Colonel C. Swinhoe.—On the Genus Urothoë and a New Genus Urothoides: Rev. Thomas R. R. Stebbing.—List of Birds collected by Mr. Ramage in St. Lucia, West Indies: P. L. Sclater.—On the Relations of the Fat-bodies of the Sauropsida: G. W. Butler.

UNIVERSITY COLLEGE BIOLOGICAL SOCIETY, at 5.—The Defence of Plants against Animals: F. Ernest Weiss.

WEDNESDAY, NOVEMBER 6.

GEOLOGICAL SOCIETY, at 8.—Contributions to our Knowledge of the Dinosaurs of the Wealden, and the Sauropterygians of the Purbeck and the Oxford Clay: R. Lydekker.—Notes on a "Dumb Fault" or "Wash-out" found in the Pleasley and Teversall Collieries, Derbyshire: J. C. B. Hendy. Communicated by the President.—On some Palæozoic Ostracoda from North America, Wales, and Ireland: Prof. T. Rupert Jones, F.R.S.

ENTOMOLOGICAL SOCIETY, at 7.—Notes on the Entomology of Iceland: Rev. Dr. Walker.—Additional Notes on the Genus Hilipus: Francis P. Pascoe.

UNIVERSITY COLLEGE CHEMICAL AND PHYSICAL SOCIETY, at 4.30.—The Nature of Electricity: Dr. A. H. Fison.

THURSDAY, NOVEMBER 7.

LINNEAN SOCIETY, at 8.—On a Collection of Dried Plants chiefly from the Southern Shan States, Upper Burma: Colonel H. Collett and W. Botting Hemsley, F.R.S.

CHEMICAL SOCIETY, at 8.—The Isolation of a New Hydrate of Sulphuric Acid existing in Solution: S. U. Pickering.—Further Observations on the Magnetic Rotation of Nitric Acid, of Hydrogen Chloride, Bromide and Iodide in Solution: Dr. W. H. Perkin, F.R.S.—On Phosphoryl Trifluoride: T. E. Thorpe, F.R.S., and F. T. Hambly.—On the Acetylation of Cellulose: C. F. Cross and E. Bevan.—On the Action of Light on Moist Oxygen: A. Richardson.—Anhydracetophenonebenzil and the Constitution of Linius lepideus: Drs. Japp, F.R.S., and Klingsman.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Viking Age, 2 Vols.: P. B. du Chaillu (Murray).—Alternative Elementary Chemistry, 2nd edition: J. Mills (Low).—Charts of the Constellations: A. Cottam (Stanford).—The Birds of Oxfordshire: O. V. Aplin (Oxford, Clarendon Press).—Topics in Geography: W. F. Nichols (Boston, Heath).—An Introduction to Chemical Science: R. P. Williams and B. P. Lascelles (Ginn).—Five Months' Fine Weather in Canada, &c.: Mrs. Carbutt (Low).—Survey of India Department Report, 1887–88 (Calcutta).—Science of Every-day Life: J. A. Bower (Cassell).—The Teacher's Manual of Geography: J. W. Redway (Boston, Heath).—Elementary Physics: M. R. Wright (Longmans).—Experimental Science: G. M. Hopkins (Spon).—Special and Atomic Energy, 2 parts: F. Major (Eyre and Spottiswoode).—Introductory Lessons on Quantitative Analysis: J. Mills and B. North (Chapman and Hall).—Elements of Physiology: J. H. E. Brock (Chapman and Hall).—Solutions to the Questions set at the May Examinations of the Science and Art Department, 1881–86, Machine Construction: H. Adams (Chapman and Hall).

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