THURSDAY, MARCH 28, 1889.

THE NEW TRAVELLER'S GUIDE TO SCIENTIFIC INQUIRY.

Anleitung zu wissenschaftlichen Beobachtungen auf Reisen. In Einzel-Abhandlungen, herausgegeben von Dr. G. Neumayer. Second Edition, Two Volumes. (Berlin, 1888.)

"TO provide the numerous German travellers and dwellers in foreign lands with a simple introduction to scientific investigation in the various departments of natural science" was, in their own words, the object of the promoters of the present work, and this notice is an endeavour to point out, in the first place, the mode in which it has been carried out; and, in the second, to consider how far the effort has been crowned with success.

In its new shape, the book appears with a somewhat smaller size of page, and the matter is so disposed in two volumes, that the one contains the physical, and the other the biological, articles. Thirty-one collaborators have contributed as many different chapters on the various subdivisions of the subject, and, strictly speaking, each of these ought to have a detailed *critique* to itself. Considerations of space, however, forbid this mode of treatment; and hence it must suffice to enumerate the headings of the articles, and to add a few remarks explanatory of their contents in those cases where it seems advisable, premising that no disparagement is implied regarding any which are passed by without comment.

The first chapter, on "Determination of Geographical Position," by Prof. Tietjen, is eminently practical in tone; the instruments employed are briefly characterized, and instructions given for using and correcting them. The same may also be said regarding Dr. Jordan's "Topographical and Geographical Observations." We are glad to observe that both these authorities advise the traveller to depend less upon the fine graduation of his instruments than upon his ability to estimate divisions: work accomplished by the latter means is incomparably more rapid and decidedly less liable to error than that carried out by the aid of more complicated apparatus.

A most important section is that on "Geology," by Von Richthofen, of which we need only now say that it is an abstract of an independent work by the same author, which was reviewed in these columns a few months ago (NATURE, vol. xxxvii. p. 603).

Prof. H. Wild, of the Central Observatory at St. Petersburg, gives, within the compass of about thirty pages, an adequate summary of the present state of our knowledge regarding "Terrestrial Magnetism," as well as a description of an apparatus suitable for travellers, with directions for its use. Observations upon land only are here discussed, those on board ship being reserved for special treatment in the sequel. The article "Meteorology," by Dr. J. Hann, of Vienna, is commendable, amongst other things, because it informs the traveller what he need not do. A passage of this nature comes upon the traveller, overwhelmed by the multitude of minute instructions, like an oasis in the desert. Nevertheless, the directions regarding what ought to be done are none the less explicit, and the concluding observations are dictated by sound common-sense:—to use only instruments by the most trustworthy makers; to enter in the note-book the *uncorrected* observations; and not to modify, even though it were apparently to improve, a scheme of observations once commenced.

Prof. Weiss treats of the zodiacal light, meteoric showers, refraction, and other "Phenomena which can be observed without the use of Instruments"; but his disquisition seems to us of rather needless length, and the more so because, as the author himself reminds us, "the circle of observations of this kind, which promise a profitable harvest to the traveller, is becoming continually smaller."

Concise, but thoroughly scientific, is the statement of the principles and practice of "Nautical Surveying," by Dr. Hoffmann. We cordially agree, amongst other things, with the dictum that instruments which serve a variety of purposes are always to be distrusted, and that, though they may be taken by land-travellers when considerations of space and weight are paramount, they are quite inexcusable on board ship.

In three succeeding chapters the subject of "Tidal Observations" is treated by Dr. Börgen, and the "Determination of the Amount of Water flowing in Rivers" by Von Lorenz-Liburnau; whilst a very useful general sketch, entitled "Hints for the Observation of the Intercourse of Nations," is contributed by Dr. Moritz Lindeman. A short, but interesting article, entitled "Some Oceanographic Problems," which, by a strange oversight, is omitted from the table of contents, has been written by Dr. O. Krümmel, whose work on the currents of the Falkland Islands is well known, and whose little text-book has been favourably noticed in these columns (NATURE, vol. xxxv. p. 6).

The editor's own contribution to the series is of a very modest character, and consists of a series of supplements to some of the chapters above referred to, showing under what limitations, and with what special precautions, such observations must be carried out on board ship. It is subdivided into two sections, the first of which is hydrographic in its scope, and handles some very interesting topics; for instance, the action of the wind upon the sea, the application of meteorology to navigation, materials carried by currents, and so forth. These are treated with great care and precision; and, as an instance of the way in which the whole is brought up to date, it may be mentioned that the Hon. Ralph Abercromby's invaluable photographic work upon clouds, though only published very shortly before the present volume, is duly noticed. The second subdivision is devoted to magnetic observations, and deals fully with the mode of making these on board ship, and also of determining the appropriate coefficients for their correction.

In the new edition this concludes the physical division of the work, for the chapter on "Earthquakes" has been omitted, on the ground that seismology has now developed into such a special and complex study that the traveller cannot be expected to undertake it. What is essential for him to know on this head has been incorporated in the chapter on "Geology."

The biological volume opens with an introductory essay by Dr. A. Meitzen, headed "General Topography, Political Geography, and Statistics," the bulk of which is cast in a catechetical mould, furnishing useful hints to the traveller as to the best arrangement of his queries so as to elicit materials for a complete account of a country or district. Dr. A. Gärtner's chapter, on the anatomical, physiological, and medical investigations which may be undertaken by those practitioners who have the opportunity, is much to be commended for its conciseness and completeness. We should like to see it reprinted, and a separate copy placed in the hands of every military and naval surgeon. Agriculture receives the full share of treatment to which it is entitled. Prof. Orth, of Berlin, deals with the subject in general, with special reference to the composition of soils, whilst cultivated plants are separately handled by Dr. L. Wittmack.

The "Geographical Distribution of Plants" is discussed by Dr. O. Drude, upon the same limes as were adopted by Grisebach in the first edition of the work. Fifteen floral regions are recognized, grouped under six larger divisions, and the classification of plants, according to their general biological relationships, is reproduced with certain modifications. The "Geographical Distribution of the Sea-grasses" (which name is here restricted to the marine Phanerogams) is very fully set forth by Dr. Ascherson, all the species being enumerated and defined. The important topic of the modes of "Collecting and Preserving Plants of higher rank (Phanerogams)" has been committed to no less an authority than Dr. G. Schweinfurth. His mode of arranging the matter of his contribution in short numbered paragraphs makes it easy of reference, and the style is a model of terseness and perspicacity. The use of a portfolio in collecting is recommended, instead of the usual vasculum; and the relative merits of preservation in spirit, or by drying and pressing, are carefully considered, the preference being given (rightly, we think) to the former. The three sections just enumerated complete the botanical part of the work, which seems to us in its general arrangement the least satisfactory part of the whole. That such an insignificant group as the marine Phanerogams should have the same number of pages allotted to it as are given to all the rest of the higher plants, whilst the Cryptogams are entirely unnoticed, is hardly in accordance with the relative importance of these different classes of plants.

The editor of the volumes has not forgotten that "the proper study of mankind is man," for no less than four chapters, by as many different authors, treat of the investigation of the phenomena presented by the genus *Homo*. Dr. A. Bastian opens the series byan interesting dissertation upon "The General Scope of Ethnology," wherein a list is drawn up of eighteen different environmental factors, physical and biological, and a number of suggestive remarks are added upon each of them. The difficult subject of "Linguistic Inquiry" is next fully discussed by Dr. Steinthal, and that of "Numeration" by Dr. H. Schubert; whilst from the veteran pen of Prof. Rudolph Virchow, we have a masterly essay upon "Anthropology and Prehistoric Investigation," which is equally remarkable for its attention to practical details and its philosophic co-ordination of results.

The seven succeeding sections are devoted to instructions for the collection and preservation of various forms of animal life. The "Mammalia" have been undertaken by Dr. Hartmann. That this contribution is the work of an expert is obvious from numerous minutiæ, as, for example, when he warns the traveller, in a footnote, not to wear metal or mother-of-pearl buttons, or he will be continually annoyed by the natives begging for them. But though the matter is good, we cannot commend the style of this article: it is too verbose for a work of this character, and not only does the author perpetrate some choice examples of German prose composition, but his enthusiasm at times leads him into descriptive passages of tropical life and scenery. A welcome novelty in this edition is a chapter specially devoted to the "Cetacea," by Dr. H. Bolau, in which we notice with satisfaction that the desiderata of our museums are specially recorded. Dr. Hartlaub's treatment of the "Birds" is very full, and bristles with apt quotations from various authors: one, from the pages of Darwin's "Journal," might very appropriately stand at the head of the whole biological section of the present work: "It is better to send home a few things well preserved than a multitude in bad condition."

The section upon the "Collection of Reptiles, Batrachia, and Fishes," by Dr. Günther, of the British Museum, is quite a model of the way in which work of this kind should be done. The instructions are full and clear, but yet concise, and no extraneous matter is inserted. The "Mollusca," "Marine Invertebrata," and "Arthropoda" are communicated respectively by Dr. Ed. von Martens, Prof. Möbius, and Dr. Gerstaecker, whose names are a sufficient guarantee for the scientific value of the work they have undertaken. The practical nature of the articles, moreover, seems quite on a level with their zoological merit.

Dr. Gustav Fritsch completes the volume by a brief treatise upon two very important subjects—the microscope and photography. This latter has, owing to the perfection of the dry-plate methods, become so easy of practice that no scientific expedition is completely furnished without a photographic outfit; and it is satisfactory to see its various uses brought prominently forward in a work of this kind. Special attention may be called to the mode of recording the topographical features of a country by means of panoramic photographs taken from properly selected points of view, and to its peculiar advantages for the collection of anthropological data.

The editor is to be congratulated on the manner in which his task has been carried out. We have noticed a few, but not many, misprints uncorrected in the errata: "Du Petit-Thonars," for instance, appears in the same place in both editions. Compared with previous works of the same kind, this one is beyond comparison the fullest and most detailed: it contains, for example, about three times as many pages, and these more closely printed, than our own "Admiralty Manual of Scientific Inquiry," so that as regards quantity of information the two works are hardly to be placed in the same category. This, however, may not be altogether advantageous, since the German work, if read by an intending traveller, might not improbably deter him from any inquiries by seeming to exact too much. The English book might be termed a practical hand-book of the subject, whilst the German one is an encyclopædia. In our opinion it would best aid the objects it has in view by being published in the form of small separate works, and we should like to see it adapted into a series of such in the English language.

W. E. H.

PLANT LIFE.

Pflanzenleben. Von Anton Kerner von Marilaun. Erster Band. Gestalt und Leben der Pflanze. (Leipzig, 1887.)

THIS is a book which deserves the warmest welcome from all lovers of plants. To give a general and at the same time a full and accurate survey of the natural history of plants, is at the present time a task of immense difficulty, and one which very few botanists could undertake with any hope of success. The task is daily becoming more difficult, as new additions are made to the already huge accumulation of facts, while its efficient performance is now a matter of more importance than ever, if botany is to be saved from becoming a close science, for specialists only. It may be said at once that the author has done his work with remarkable success. The book is a large one ; only the first volume is before us, and this contains 734 large octavo pages. Yet it is scarcely an exaggeration to say that there is not a dull page from beginning to end of the bulky volume. On the other hand, inaccuracies are met with here and there, and some of these are serious, but the general excellence of the book is but little affected by these faults.

Before entering on a fuller account of the text, we must say a word about the illustrations, which are among the greatest merits of the book. In the text are 553 figures, many of which are pictures of great beauty. In addition to these there are twenty coloured plates, the first of which is histological, while all the rest represent various aspects of vegetation, both terrestrial and aquatic, in different parts of the world. Many of these plates are accompanied by an outline tracing of the individual plants shown, each figure on the tracing bearing a reference number, while the names are given below. This is an excellent plan (already frequently employed by French zoologists), and adds much to the practical value of the plates.

We will endeavour to give some idea of the plan of the work so far as it extends at present, but only a very cursory view will be possible. The present volume may be said to deal with general organography and physiology, especially of the vegetative organs. Comparatively little space is given to the organs of reproduction, which will no doubt receive full attention in the second volume, dealing with special morphology.

The introduction is headed, "The Investigation of the Vegetable World in Ancient and Modern Times." It contains a general view of the history of the science. This is very well done, and is calculated to rouse the interest of the reader.

Chapter I. is on the living substance of plants ("Das Lebendige in der Pflanze"), and may be described as an outline sketch of histology. The discovery of the cellular structure of plants by the naturalists of the seventeenth century is first narrated, and some of Nehemiah Grew's classical figures are here reproduced. Protoplasm and its movements next receive attention, and in this section there is some room for criticism. Thus the well-known motile granules of Closterium are wrongly described as being embedded in the protoplasm (p. 34), and the difficult question of the movements of Diatoms will scarcely find its solution in the theory here advocated, according to which Diatoms move in much the same way as mussels ! In the following section the nucleus and chlorophyll-bodies are treated too much as if they were of the nature of secretions from the protoplasm, like oil-drops or crystals, whereas in all cases of which we have any definite knowledge they originate solely by the division of pre-existing bodies of the same kind. Probably, as regards the chlorophyll-corpuscles, the author wrote under the influence of the somewhat doubtful observations of Mikosch. The division of the nucleus is described by the author later on in the volume, but it would have been well to lay more stress on the process in this place. The remarks on the continuity of protoplasm through the cell-wall are acute and interesting, but it is rashly assumed, in opposition to the most trustworthy investigations on sieve-tubes, that this continuity exists from the first origin of the cell-wall. The author's attempt to identify the intercellular protoplasmic threads with the achromatin fibrils formed during cell-division is equally open to criticism.

The second chapter (pp. 51–246) deals with the absorption of food. This is a striking chapter, and presents in a very attractive manner a part of the science which is too often made to appear excessively dry. Attention may be called to one or two especially good sections, such as those on the nutrition of water-plants and of "stone-plants." The remarks on the correlation between the position of the leaves and the distribution of the roots, as affecting the water-supply of the plant, are of great interest, and are illustrated by excellent figures (pp. 85–92). Saprophytes, insectivorous plants, and parasites are all fully and vividly described. As regards the parasites especially, the account here given is the best general one with which we are acquainted, and the illustrations are as good as the text. Lathræa is reckoned among insectivorous plants as well as among parasites, and the author's peculiar theory as to the nutrition of this plant by means of alleged protoplasmic fibrils projecting from the surface of its glandular hairs, is again brought forward (p. 128). This view must now be regarded as more than doubtful. The section on the absorption of water (pp. 199–223), is perhaps the least satisfactory in the book. The most heterogeneous organs, extra-floral nectaries and chalk-glands among the rest, are classed, on the slightest possible grounds, among organs for the absorption of water, and thus their true functions come to be overlooked. It is difficult to understand how so forced and fanciful a theory can be maintained by any good observer. The short section on symbiosis is clear and satisfactory, and Frank's views on the vexed "Mycorrhiza" question are well put forward.

Chapter III. (pp. 247–343) is on the conduction of food. Root-pressure, transpiration, and the ascent of water through the wood are well discussed, Godlewski's views on the last-mentioned subject being provisionally adopted. The whole question is treated as clearly as is possible, in the present state of our knowledge, in a popular book. The detailed account of the structure of leaves as affecting transpiration is particularly good, and the illustrations here deserve the highest praise. The concluding sections of this chapter are concerned with the fall of the leaf, the relation of transpiring surface to water-conducting tissues, and the conduction of gaseous food-substances.

The subject of Chapter IV. (pp. 344–420) is the formation of organic substances from absorbed inorganic food. Assimilation (in the narrower sense) is fairly described, but the view taken of the action of light on the process has been, perhaps, too much influenced by Pringsheim's "screen-theory" of chlorophyll. Pages 380–393 contain an excellent series of figures to illustrate what is termed "leaf-mosaic," or the relation of the form to the arrangement of leaves, as insuring the exposure of the maximum surface to light. At the end of the chapter the adaptations by means of which assimilating leaves are protected against the attacks of animals are well described.

Chapter V. (pp. 421–475) treats of the metabolism and translocation of food-substances ("Wandlung und Wanderung der Stoffe"). The chapter begins with a few remarks on some of the characteristics of carbon compounds. The usefulness of such a very concise treatment of so vast a subject may be doubted, but the account appears to be good, so far as it goes.

The question of the first product of assimilation in green plants is clearly treated, and then the chief organic substances occurring in plants are described. Under the head of the translocation of food-substances, the structure of the phloëm and of laticiferous tissue is explained, and the anatomical anomalies of climbing plants are shortly described from this point of view. The figures given to illustrate the last-mentioned peculiarities of structure are, as so often happens in such cases, diagrammatic and unsatisfactory. The important subjects of respiration and fermentation are also included in this chapter, and the relation between these two processes is clearly brought out.

In the sixth chapter (pp. 476–544) the growth and construction of the plant are treated of. Under the former head we have an exposition of the mechanics of growth, and of the influence upon it of light and heat. The second part of the chapter includes an account of cell-formation. This section, unlike the rest of the book, seems to us insufficiently illustrated. Nuclear division is represented in a few figures taken from Guignard, but the subject is not treated with any completeness.

Chapter VII. (pp. 545–734), the last in the volume, is devoted to general organography ("Die Pflanzengestalten als vollendete Bauwerke.") The transition from unicellular plants to the most complex forms is first rapidly traced. Then we have sections dealing very fully with the modifications of the leaf, the stem, and the root respectively. In the first of these sections there is an especially good account of the cotyledons, and many interesting facts about germination are described. The section on leaves ends with a short account of the morphology of the flower. It is to be regretted that the author, after severely criticizing the artificial character of some former explanations of the morphology of the ovule, himself makes a laboured attempt to prove that the ovule is always homologous with a leaf or portion of a leaf (p. 603).

As regards the organography of the stem, special attention may be called to the excellent account of the stems of "lianes" (pp. 629–669), and to the clear explanation (founded on Schwendener) of the mechanical construction of upright stems. Here, however, as is usual in such explanations, the thickened stems of Dicotyledons scarcely receive their due share of attention. Under the heading "Hochblattstamm," the special forms of branching characteristic of inflorescences are explained.

The last section is on the construction of the root, and on its movements in response to external stimuli. Full justice is done to this very interesting subject, and the author is quite justified in emphasizing the unsatisfactory nature of those crudely mechanical explanations of these phenomena which are so often given in physiological treatises.

In the rapid survey we have taken it has been difficult to give a correct impression of the volume as a whole. It has been necessary to notice several defects, which have inevitably become more prominent in our review than they are in the book itself. The work is written throughout in a good clear style, and if the concluding portion fulfils the promise of the first volume, the treatise may certainly claim to rank as the best account of the vegetable kingdom, for general readers, which has yet been produced. D. H. S.

PRACTICAL ELECTRICAL MEASUREMENTS.

Practical Electrical Measurements. By James Swinburne. (London: H. Alabaster, Gatehouse, and Co., 1888.)

THIS is a suggestive little book; and the pity is that the idea of the author, in writing the articles of which it is practically a reprint, has not been a great deal better carried out. The articles were evidently poor in style and excessively incomplete, even taken as newspaper articles; and, when put together in a consecutive form, the "nakedness of the land" becomes too painfully apparent. As it stands, the book consists mainly of remarks on almost every form of instrument known in electric lighting. It has no pretence to be a complete treatise, even of an elementary kind, on practical electrical measurements in general. Many of the most important branches of electric measurement are not even mentioned. What we do find is, partial descriptions of a multitude of instruments and machines, and a good deal of criticism, not always in good taste, and often pretty wide of the mark, of these instruments, and of the ideas of other "engineers."

The author commenced by setting himself the nearly impossible task of writing articles on electric measurement without the use of mathematical symbols. "The pedantic fashion," he says, "of dragging mathematical symbols into all electrical literature, and the respect commanded by an analytical investigation, even on false data, often lead writers to mar work otherwise good, by getting out of their mathematical depths, and writing nonsense to look learned." This, which is not unlike a good deal of the criticism throughout the book, sounds rather like putting on grandfather's spectacles to look sage; but, supposing that others do drag in more mathematical symbols than are absolutely necessary, it seems rather extreme to punish oneself by thrusting them aside altogether. To give really useful information as to the employment of electrical measuring instruments without quoting the formulas which are necessary in connection with them and with their errors and corrections seems to us to be leaving out the very crown of the whole; and as to the "respect commanded by an analytical investigation" founded on false data, we trust it could never become a temptation to our present author.

But besides the difficulty of writing on electrical measurement without mathematics, there is, in our opinion, an attempt to catalogue and describe far too great a number of instruments and methods. In making this criticism, we cannot support it by mentioning names; but the author knows well, and everyone else knows, that many of the instruments and methods to which space is devoted are absolutely worthless; and it would be infinitely better to omit them, and thus both avoid confusion and save space, which might well be given to those that are of importance.

Altogether, the book requires re-writing, by which it could undoubtedly be made of very considerable value. The style is not good. With a sort of self-consciousness, Mr. Swinburne calls himself "the writer" throughout. Some of the criticisms—for example, that on the "B. A. Committee" (p. 22), and a remark on one of our most highly-valued scientific men (p. 110)—are altogether out of taste, coming from the pen of one who has his reputation still to win.

OUR BOOK SHELF.

Galileo and his Judges. By F. R. Wegg-Prosser. (London: Chapman and Hall, 1889.)

THIS work is a temperate discussion of the vexed question of the treatment of Galileo by the Pope and the Congregation of the Inquisition. The facts are not new; Mr. Prosser puts himself unreservedly in the hands of M. Henri de l'Epinois, whose article in *La Revue des Questions Historiques* is well known, and who has, Mr. Prosser says, gone to the trouble of consulting at first hand all the documents that could be found at the Vatican bearing on the subject. Mr. Prosser, in drawing his conclusions from the facts, adopts a kind of middle ground. He is a Catholic, and though he is too sensible a man to follow many of the Catholic writers in their conclusions, yet he seems to be shocked at the standpoint taken by a few of the Catholic writers who have condemned the treatment of Galileo. Thus he occupies a position between keen controversialists like the late Dr. Ward, on the one hand, who hold that not only did the Congregations act within their rights and their legitimate sphere, but that, looked at from the point of view of the early part of the seventeenth century, they acted wisely and prudently, and Catholic writers like Dr. Mivart, on the other hand, who assert (these are Mr. Prosser's words) "that the Church has no authority to interfere in matters relating to physical science, and that the issue in the Galileo case has proved the fallacy of her attempting to do so; that without entering into the discussion of what ought or what ought not to have been done in former times, we of the present generation have evidence sufficient to show us that scientific investigations should by right be free from the control of ecclesiastical authority." The first step taken by the Church against Galileo was in 1616, in censuring him for his teaching, and warning him of the consequences if he continued to teach the doctrines, first, that the sun was the centre of the universe, and therefore locally immovable; second, that the earth was not the centre of the world, and moved round itself diurnally. The first doctrine was declared by the Qualifiers—that is, the committee appointed from the Congregation of the Inquisition—to be foolish and absurd from a philosophical point of view, and heretical since it contradicted the meaning which had been given to certain passages of Scripture by the Church. Galileo promised to obey the warning, "*ut supra dictam opinionem . . . omnino relinquat, nec eam de cetero quovis modo doceat teneat aut defendat verbo aut scriptis.*" Mr. Prosser enters into a very long argument to show that this decree of 1616, though founded on reasons of doctrine, was merely disciplinary, and not given on a matter *de fide*, in which he is now and then rather casuistical. Galileo after this remained in peace till he was summoned to Rome to answer for the printing and publishing of his "Dialogue" in 1632. The heads of accusation are set out at length in the present work, but substantially they come to this, that he had disobeyed the order of 1616, and had continued to teach the same doctrines as those for which he was then reprimanded. It is impossible not to see that in summoning him to Rome the Pope was to some extent actuated by feelings of pique, for the fool of the "Dialogue," Simplicio, undoubtedly represents His Holiness. Mr. Prosser goes on to show that, having regard to the state of knowledge at the time, the Inquisition could have done nothing else but convict Galileo. The defence of the latter was threefold. In the first place, he said that Bellarmine had informed him that he might hold the Copernican doctrine as an hypothesis. This was undoubtedly the case; but it appears as something more than an hypothesis in the "Dialogue." Galileo answers to this that he had merely put the theory in the mouth of a speaker whose teachings were combated by the other speakers. Secondly, he maintained that he had not contravened the order given to him not to teach or expound that abominable doctrine in any way. This is hardly correct, as the "Dialogue" will show. Thirdly, he declared that he did not remember having been forbidden to teach it. But he could hardly have forgotten the terms of the order of 1616, which have been quoted above, nor the rebuke given him by Bellarmine by order of the Pope.

Observations on the Embryology of Insects and Arachnids. By Adam Todd Bruce, B.A. of Princeton College, Ph.D. of Johns Hopkins University. A Memorial Volume. (1887.)

THE subject-matter of this volume formed the thesis submitted by the author when he presented himself for the degree of Ph.D. at the Johns Hopkins University. After his lamented death, in 1887, the thesis was reprinted, exactly as he wrote it, as a memorial volume. He had made many additions to the work which is here recorded, but as the notes were unaccompanied by drawings it was impossible to make use of them. An account of the life and scientific work of the author is written by Prof. W. K. Brooks. The early death of Dr. Bruce, at the age of twenty-seven, prevented any very extensive amount of scientific research. It will, however, be clear to any reader of the careful and excellent work contained in this paper, that American biological science has lost an investigator of the very highest promise. Dr. Bruce had also very carefully studied, in conjunction with Prof. Brooks, the early stages of the development of Limulus, and it is much to be hoped that these results may be published at no distant date. A thorough study of the earliest stages of this most interesting form by so careful an embryologist would be extremely valuable. Prof. Brooks informs us that the work included "the segmentation of the egg, the formation of the blastoderm and of the germ-layers, and the anatomy of the young larva . . . illustrated by nearly a hundred drawings." I mention this in the hope that some means of publication may be found in this country, if the claims upon the space of the *American Journal of Morphology* are too great to admit of the appearance of a paper on so important a subject in what appears to be its appropriate position.

The volume contains an attempt to settle the most difficult questions concerning the earlier stages of the development of spiders, Lepidoptera, Coleoptera, and Orthoptera, while less complete observations were made upon Neuroptera and Diptera. Among insects, the Lepidoptera were studied with especial care, the type selected being *Thyridopteryx ephemeraiformis.* The careful account of this embryology, together with the numerous excellent figures, entirely substantiate the author's claim that the study of this type, "if it has brought to light nothing new, has, in the opinion of the writer at least, settled some important points connected with the embryology of this group of insects." In the account of segmentation and the formation of the blastoderm, the author completely confirms Bobretzky's descriptions. The development of *Thyridopteryx* occupies twelve quarto pages: for the details the original must be consulted. The account of the embryology of Orthoptera, represented by *Mantis* and the grasshopper, and of the embryology of spiders, is also very complete.

At the end of the paper many interesting and suggestive conclusions are appended. Among these it is significant that a writer who has done so much work upon the early stages of Limulus should unhesitatingly regard this latter form as an Arachnid. The Trilobites he considers as "possibly the ancestral form of Limulus."

Only a short account of this excellent paper has been given here. All those interested in embryology, and the light shed by it upon morphological science, will, of course, make a careful study of this work. E. B. P.

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 Satellite of Procyon.

It is well-known that Procyon, like Sirius, does not travel through space in a straight line, its motion undergoing changes similar to those which would result from the disturbing action of a large satellite. This explanation was advanced by Bessel in 1844, and though the satellite has not yet been *seen*, its existence has been placed beyond reasonable doubt by Dr. Auwers's investigations on the subject.

Does it not seem probable that this interesting body may be revealed by the aid of photography? It is now possible to photograph stars and nebulæ which are beyond the visual range of the most powerful telescopes; and if the companion of Procyon, like that of Sirius, be self-luminous, there would seem to be a good prospect of obtaining its image on the sensitive plate.

As the companion is doubtless in pretty close proximity to its brilliant primary, it will be necessary, for photographic purposes, to intercept the image of the latter by means of a suitable screen. Since the *direction* of the satellite at any time can be found from Dr. Auwers's elements,[1] there would be no uncertainty as to the position in which this eclipsing disk (or wire) ought to be placed, though its proper adjustment would be a somewhat delicate operation. Should the satellite be photographed, its position will become known from its configuration with respect to other stars recorded on the negative.

If a very large telescope were employed, the images of both components, as distinct and separate dots, might be obtained on the plate. For Procyon, a very short exposure would be requisite, and this could be secured by the use of a movable stop or screen, similar to that devised by Prof. Pritchard, and used for parallax work at the Oxford University Observatory.

It is scarcely necessary to dilate upon the interest which would attach to a photograph showing Procyon's companion. As the parallax of Procyon has been satisfactorily determined by Dr. Elkin and others—being 0''·266 according to the Yale College observations—we could ascertain the *actual* as well as the *relative* masses of the two components. And the brightness, or more strictly speaking the photographic magnitude, of the satellite might also be determined with some precision.

[1] At present the position-angle of the satellite is *about* 233°. Its *distance* probably amounts to but a few seconds of arc, and may be within 2''.

It may not be too late to obtain such results during the present season, but exposures of four or five hours, under good conditions, will not be practicable before next winter.

J. M. Barr.

St. Catharine's, Ontario, Canada, March 4.

"Les Tremblements de Terre."

The issue of Nature for February 7 (p. 337) contains a review of the little work on earthquakes published for me by Messrs. J. B. Baillière. The anonymous author of the article makes several criticisms on my book to which I desire to reply.

Your critic thinks it a grave fault not to have entered into a detailed description of the seismographs and seismometers at present in use. He reproaches me in particular for having but just mentioned Prof. Ewing's duplex pendulum seismograph; for having omitted to speak of the same inventor's horizontal pendulum seismograph; and especially for seeming to ignore the experiments made with these instruments by Prof. Ewing in Japan. I confess that I had not been struck by the excellence of the instruments in question, and that it was not through an oversight that I omitted to describe Prof. Ewing's observations in Japan, while I quoted in detail those of his *confrères*, Messrs. Milne and Gray, in the same country.

Your critic defends with some acerbity a certain class of seismographs, and wrongly accuses me of failing to appreciate the principles on which their construction is based. The objections which he makes to my treatment of M. Cavalleri's pendulums of unequal length are entirely refuted from a theoretical point of view by the learned note due to M. Poincaré, which is inserted on p. 46 of my book. I need not insist further on this point.

Your critic thinks I have not done sufficient justice to the work of the Italian *savants*: he forgets the limits necessarily imposed on a book destined especially to give to the general public an idea of the present state of an important question.

The writer of the article regards the seismographs of to-day as perfectly sufficient for all scientific needs. I am far from being the only person engaged in the study of earthquakes who does not share this opinion. Finally, he describes, and not very clearly, the experiments which I made with M. Michel Lévy to measure the rate of propagation of disturbances through the soil, and the registering apparatus designed for this purpose. According to the writer, these experiments constitute the only advances we have made in the study of earthquakes. If he had rendered justice to our work on the subject, we should have been content, and I should have raised no objections to his article. But your critic reproaches us with having given results which are masked by inevitable causes of error. A more careful study of the book, and especially of the extracts from our original memoir, published in the *Comptes rendus* for 1885 and 1886, would have preserved him from so inexact an assertion. In fact, he unjustifiably mixes up the *preliminary* experiments, made at Le Creusot by means of an apparatus exactly similar to that used by Mallet and Abbott,[1] with what really constitutes the basis of our work—I mean the determinations made with the aid of photographic registration and explosives. What your critic calls the "personal equation" of the instrument is here nearly negligible[2]; and the merit of our method lies precisely in this point, which distinguishes us from our predecessors.

We would beg the readers of Nature to verify for themselves the truth of our statement. This verification will enable them to judge of the value of the article laid before them.

F. Fouqué.

Finding Factors.

It may add interest to Mr. Busk's ingenious method of distinguishing between prime and composite numbers to state the algebraic basis on which it rests.

Let N be any number, and n^2 the next higher square number, and let $N = n^2 - r_0 = (n + 1)^2 - r_1 = (n + 2)^2 - r_2 =$ &c. r_1, r_2 are formed successively from r_0 by the successive additions of $2n + 1$, $2n + 3$, . . . the increments being in arithmetic progression, so that $r_m = r_0 + 2mn + m^2$. As soon as r_m becomes a square, N is expressed as the difference of two squares, and its factors are found.

[1] See p. 219 *et seq.*

[2] The only subsisting cause of error is that due to the inertia of the mercury, which we have estimated and introduced into all our calculations (see p. 246).

If N is prime, it is expressible as the difference of two squares in only one way, viz. $\{\frac{1}{2}(N + 1)\}^2 - \{\frac{1}{2}(N - 1)\}^2$. To prove that N is prime by this method, the number of additions required is $\frac{1}{2}(N + 1) - n$, which is $\frac{1}{2}\{(n - 1)^2 - r_0\}$.

It may be noticed that when $n + m$ and r_m have a common measure, it must be a factor of N, and the additions need be continued no further.

For example, $N = 8131, n^2 = 8281.$

$n = 91$	$r_0 = 150$
	183
$n + 1 = 92$	$r_1 = 133$
	185
$n + 2 = 93$	$r_2 = 518$
	187
$n + 3 = 94$	$r_3 = 705$

94 and 705 have a common measure, 47; therefore 8131 is is divisible by 47, and the other factor is then found to be 173.

Mr. Busk's method of shortening, exemplified on p. 414 by his proof that $73 = 37^2 - 36^2$, depends upon the following:

Let $r_0 + 2mn + m^2 = (k + m)^2$, then $m = \frac{1}{2}(k^2 - r_0)/(n - k)$: since $k^2 - r_0$ is even, k is even or odd according as r_0 is even or odd; it is necessary only to try values of k descending by differences of 2; the greatest possible number of operations is $\frac{1}{2}(n - 1 - k_0)$, when k_0 is the value of k, with which we begin.

The process may conveniently be arranged as in the following example:

Let $N = 6667, n^2 = 6724 = 82^2, r_0 = 57.$

k		$82 - k$		$\frac{1}{2}(k^2 - 57)$		Quotient.
15	...	67	...	84	...	a fraction
				32		
17	...	65	...	116	...	"
				36		
19	...	63	...	152	...	"
				40		
21	...	61	...	192	...	"
				44		
23	...	59	...	236	...	4

therefore $6667 = (82 + 4)^2 - (23 + 4)^2 = 113 \times 59.$

If N is composite, this method is not always shorter than the former. It will be shorter whenever $2m > k - k_0$, but it is not easy to see how to determine *a priori* whether this is the case.

The method by decreasing squares is not one of general application. For instance, the factors of 323,171 cannot so be found. It is the difference of two squares, each more than ten times as large as the first square used.

W. H. H. Hudson.

King's College, London, March 15.

Dolomedes fimbriatus, Clerck, at Killarney.

It may interest some of your readers to know that this rare and fine aquatic spider occurs on Cromaglaun Mountain, near Killarney Lakes. I first found it when collecting the little shell, *Limnæus involutus*, and though I had it two or three times in my hand, it was so active that it escaped, and I, not knowing its powers of diving, never thought of looking for it under water. The following year I again visited the little lake, which is called Crincaum, with some friends, and this time we fairly captured the spider, which I then easily identified as *Dolomedes fimbriatus*. There is a good account of it in Blackwall's "British Spiders," and also in Andrew Murray's "Economic Entomology—*Aptera*," but I am not aware that it had been observed in Ireland before I found it.

A. G. More.

March 18.

BEECH-WOOD.

It is so characteristic of the science of to-day to find specialists narrowing their field of research, and confining their investigations to a deep narrow channel, that no surprise can be felt that two able men should devote their energies for two years to the examination of the biology and chemistry of the wood of a single tree. It is not so easy to avoid astonishment at the results of the two years' work, however, appearing as they do in the form of a large book [1] of 238 pages of close description and argument, interspersed with long tables of figures, abounding in interesting information when properly read.

The authors have divided their work very fairly, the botanist having set himself the task of elucidating in detail the histology of the wood, the distribution of water, starch, and other contents, the formation of annual rings, and the growth in thickness of the trunk, and a number of other problems throwing light on the growth of the beech in the forest; while the chemist has confined himself to the task of analyzing the timber, so as to discover (1) the quantities of total ash, water, nitrogen, &c., in different parts of the tree; (2) the percentage composition of the ash, and the manner of distribution of the individual constituents; (3) the absolute quantities of each ash-constituent in 1000 parts, and other chosen quantities of dry substance of the wood; (4) the annual in-take and out-put of these constituents on a hectare of beech forest; and (5) similar particulars for the nitrogenous constituents.

The authors have by no means spared their trees. It is enough to make one envious to read of the trees cut down at all ages from 15 to 150 years, and of the specimens selected at all heights from each; how the research was extended to good, bad, and indifferent soils, and how trees in shade and in the open, trees entire and trees pruned, &c., were all laid under contribution as required. More than 100 stems of all ages were thus employed.

The manner of utilizing this enormous mass of material is worth noticing, for every kind of determination was made that would yield practical information.

The height of the trees was found, as the best indication of the value of the situation; the number of stems on a given area, their surface, contents, &c., were also determined; the age of the trees, their physiological condition, &c., were all considered in due course. The selected stems were then cut up as follows: transverse disks were cut at the successive heights of 1·3, 5·5, 10·7, 15·9, 21·1, and 26·3 metres, and separate determinations made of the specific gravity, histological peculiarities, analysis, &c., and these not only for wood and cortex separately, but also for each 30 annual rings of the stem. The thickness, density, &c., of the annual rings were also tabulated, and attention paid to north, south, east, and west sides of the stem.

Not only are all these data given in detail in the tables, but other tables are provided showing the mean densities, cubic contents, &c., &c., of whole trees, or of the trees on given areas; and the patient compilation and ingenious methods here displayed reflect the greatest credit on the authors. It is, in fact, especially in the application of their measurements, &c., to the forest as a whole that the tables will find their greatest practical value. There is also much of more abstract scientific interest to be learnt from the results.

On examining the histology of the wood, several new facts were discovered. The curious dipping in of the annual rings where they cross the broader medullary rays, and the deposits of grains of calcium carbonate on the septa of the vessels, may be mentioned by the way; but the most important results are those relating to the length of the elements, the lumina of the vessels, and the relative numbers and distribution of the latter on a square millimetre of transverse section.

The wood of the beech consists of the usual elements—vessels, tracheides, libriform fibres, and wood parenchyma, with transitional elements difficult to classify under any one of these heads. As was long ago pointed out by

[1] "Das Holz der Rothbuche," by Profs. R. Hartig and R. Weber. (Berlin: Springer, 1888.)

Theodore Hartig, Sanio, and others, the length and breadth of the various elements differ in different parts of certain trees. Prof. R. Hartig has now worked out this subject in the beech for the first time, giving long lists of measurements at various heights, ages, &c., as before.

The recent vessel-segments, tracheides, and fibres in a five-year-old beech-tree are only half as long as those in a tree 120 years old, and this occurs in what at first sight appears a very curious and inexplicable manner.

The length of these organs at first rapidly increases, until the tree is about 60 years old; then they either no longer show increase in length, or do so very slowly, till the tree is about 120 years old. They then exhibit their maximum length. Henceforward the elements formed are shorter each year, and much so if the tree is growing free in the open.

Moreover, in the same tree, the longest elements occur at the base of the trunk, and shorter and shorter ones occur up to a height of about 5·5 metres; then the tracheides and vessel-segments are found to be longer again, until the height of 15·9 metres is attained. The lengths are much less in the crown. The libriform fibres decrease regularly in length all the way up.

Hence, put generally, the elements are short in young trees and in the upper (*i.e.* youngest) parts of older ones; their lengths increase afterwards year by year, but after 120 years only shorter and shorter elements are again found.

The lumina of the vessels also vary with the age of the tree and with the height of the part. Taking, for example, the vessels at a height of 1·3 metres, the average diameter is 0·05 millimetre during the first 30 years, but between 30 and 60 years they are larger (0·064 millimetre), and maintain this average afterwards to the end of the life of the tree. Still more striking are the changes at different heights in the tree: both in very young and in very old trees the vessels in the crown may be very narrow indeed compared with those elsewhere.

As facts of great importance in its bearing on the question of the specific gravity of wood, and the futility of comparing rough weighings, we may select the following. The three elements—vessels, tracheides, and libriform fibres—are distributed very differently on the transverse section of the annual rings according to the age of the tree and the level of the section. The rule is that, at the same level, the number of vessels per square millimetre increases as the tree ages. When it is shown that the numbers may range between about 60 to 80 at 30 years, and 200 to 220 at 100 years or more, the conviction arises that the question of specific gravity may be complicated by many factors.

As regards the level of the section examined, the rule is that the number of vessels per square millimetre increases as we go upwards. But it is found that the number of vessels in any one annual ring remains about the same: it is differences in the breadth of the rings which cause the close packing or otherwise, and the general tendency of the rings to be narrower upwards explains the above.

With respect to tracheides and fibres, it may be said generally that young trees form few tracheides (and chiefly near the vessels) but more are formed later; but again, in old age, in the open, the tracheides are replaced by fibres.

Some interesting observations follow on the micro-chemistry of the wood: vanillin and coniferin occur in the walls of the wood elements, and it is somewhat remarkable that they should show a cellulose reaction quite late. Relatively small quantities of tannin are found in the cells, and drops of "wood-gum" are abundant. It is interesting to note the infiltration of the walls with tannin, and this gives the deeper colour to wood exposed to air, owing to oxidation.

The dark (false) heart of the beech is not due to the presence of much tannin, and Hartig again insists that this wood cannot be divided into heart-wood proper as distinguished from sap-wood. The false heart is a pathological production, and nearly always contains Fungi.

But perhaps the most interesting facts in this connection are those bearing on the starch-grains and their movements.

In an old beech-tree, the quantity of starch diminishes from the periphery to the centre: little or none is found within the last 50 annual rings. In the winter the outer rings will be crowded with starch, every cell of the wood-parenchyma and medullary rays being full.

It is, of course, impossible to go into the details of Hartig's experiments and measurements, but he found that under ordinary circumstances the main mass of stored-up starch does not move at all: contrary to the received opinion that the starch is all, or nearly all, dissolved in early summer, and stored up again in autumn, the astonishing fact comes out that during the development of the current year's annual ring, the cambium only takes starch from the next inner ring (and sometimes the next but one) in June and July, and that before the middle of September it is all restored.

In other words, only the two preceding annual rings yield starch to start the cambium: the completion of the new ring, its stores of starch, and the restoration of the borrowed starch, are at the expense of the work of the leaves of the current year.

Light is thrown on the subject by the following experiment—an admirable instance of the progress which is being made in the study of the physiology of plants. Two trees were completely deprived of branches and leaves, and then allowed to stand otherwise untouched: one was felled at the end of twelve months, the other at the end of two years. In both cases it was found that during the first year after the mutilation a new ring was formed by the cambium, but the mass of wood in this was only about 5 per cent. of the normal increment which would have occurred if the tree had remained intact: no trace of further increment was observable in tree No. 2 during the second year.

This 5 per cent. increment was at the expense of all the starch stored in the medullary rays and wood-parenchyma of the stem; in other words, the quantity of starch held stored in each of these trees was equivalent to the quantity of woody substance in a ring containing 5 per cent. of the normal annual amount: in other experiments the amount rose to 15 per cent. or more, but never approached that of a complete normal ring. It is noteworthy that the cambium only acquires the power to attract the whole of this stored starch under such special conditions of hunger as are induced by stopping its supplies from the leaves.

Some similar experiments, with modifications in the special cases, led to the result that the starch which comes down from the leaves—even when only sufficient to partly fill one layer of wood—is rapidly distributed *over the whole sheet of wood*, both above and below.

The question, What are the stores of starch for, if not to feed the cambium? is answered by the following. Weber's analyses show that the nitrogenous substances decrease from without inwards in the wood, just as does the starch in a normal tree; but the total proteid substances remain practically unaltered (at least they suffer no diminution) because they are not used up in building the cell-walls. Any drain on the proteids by the cambium seems to be paid back in due course by the travelling of the proteids from cell to cell.

Now it is a well-known fact that the beech, like other similar forest trees, only yields seed after attaining an age of 50 to 60 years, and that what are termed good seed-years are separated by considerable pauses. It is also well known that the production of fruit and seed "exhausts" the plant: in the case of annuals it completely drains their resources, and every apple-grower knows that the trees need "rest" after a good crop. In view of all the facts, then, it is most probable[1] that the stores of starch in the beech are put up in reserve for the enormous drain which the "seed-year" will involve, and we shall see that this idea is fully borne out by the chemical analyses, which show that certain valuable minerals are similarly stored for the seeds.

But this does not fully explain why the stores diminish inwards. Two causes are adduced for this. In the first place, a seed-year having exhausted nearly all the supply of starch, we have seen that succeeding deposits only occur in the outermost rings of wood, and so there is no restoration of the deposits deeper in the tree; secondly, some of the stored starch in the deeper layers gradually undergoes change into the drops of "wood-gum" (*Holzgummi*), of which mention was made above.

Some "practical results" of the above may now be noted, the most important being that the difference in weight between wood felled in summer and that felled in winter is, in effect, *nil*, contradicting a wide-spread assumption, and confirming a doubt which Nördlinger had already put forward. It thus follows that the want of durability in summer wood depends on other causes, and Hartig considers it due to the fact that winter wood has time to dry on the outside before the atmospheric influences are favourable for the development of Fungi, the spores of which are always about, but dormant in the cold of winter. No doubt there are other factors to be considered also, but the importance of the above has been too much overlooked or under-estimated.

Another interesting section of the work is that dealing with the formation of the annual rings. By cutting disks at equal distances apart on simultaneously-felled trees of 50, 100, and 150 years old, and measuring the breadth, &c., of the rings at eight points round the disks, some further discoveries were made. Generally put, it was found that (in the case of beeches near Munich, at any rate) the annual ring commences to form at about the end of May, the tree being already in full leaf; by the middle of June the ring is one-third its normal breadth, and is half finished early in July, attaining its normal complete state before the end of August. Hence the whole period of the activity of the cambium only amounts to about two months and a half.

As regards the parts of the tree, it is found that the active division of the cambium commences first in the twigs and small branches; it is later in the trunk proper, and begins at different parts, according to circumstances.

In the oldest trees (150 years) the cambium was found in an active state at 3 to 4 feet up, while parts above and below were still dormant; whereas in somewhat younger trees the process of ring-formation began simultaneously all up and down the trunk. In still younger trees the cambium was found to awaken first in the higher parts of the trunk. More investigation is still needed here, however, before several dark points can be regarded as explained.

Some generalizations as regards the growth in thickness of the beech deserve notice. In the crown, the annual increment—*i.e.* the quantity of wood produced by the cambium during one period of its activity—increases more or less rapidly as we proceed from the tips of the branches to their point of origin from the trunk; but this is by no means the case in the trunk itself, and several cases have to be considered.

In those trees which, owing to close crowding in the forest, have developed only feeble crowns, the annual increment is greatest just beneath the crown, and diminishes regularly downwards; and in very closely crowded trees the cambium in the lowermost parts of the stem may even *stop dividing altogether*: in such cases the ordinary mode of ascertaining the age of the tree would yield false results, for the number of annual rings at 3 to 4 feet high is less than the number of years of the tree's life. The physiological meaning of the above is, that the small leaf-area does not supply sufficient food-material to provide for the needs of the whole sheet of cambium, and the upper parts take all that is sent down, leaving none for those below.

In those trees which have well-developed leafy crowns, more exposed to light and air, the annual increment follows a rule exactly the converse of the last—the amount of wood formed per annum is greater as we proceed from the upper part of the stem to the lower. If we leave out of account the lowermost 6 to 12 feet, every gradation can be found, and in rare cases the breadth of the annual ring may be constant from above downwards.

Now comes in a remarkable discovery. If such trees as the above are suddenly exposed to full light and air, &c., by cutting down the neighbouring trees, the annual rings *in the lower parts of the stem* suddenly become much broader: no such stimulation of the increment occurs in the upper parts.

Now as to the explanation of these remarkable phenomena. There can be no reasonable doubt that the precedence shown by the upper parts of crowded trees is due to the rapid warming which they receive from the air in the spring sunshine: the lower parts of such trees, however, have to wait until the water which they absorb from the soil raises their temperature to the minimum cardinal point, and by the time the water of the soil is sufficiently warm for this, the cambium in the upper parts is far ahead, and working under such favourable circumstances that the rings maintain their greater breadth to the end. But the chief factor in the process is that the upper cambium gets the first supplies of food-substances, and in larger quantities, because lower down the diminished supplies have to spread over a larger area.

In the case of trees exposed freely to the light and air, the sun's rays warm the thinly covered soil (and its water) around the roots, and so the cambium is enabled to recommence its annual work pretty nearly at the same time over the whole stem: in this case thicker rings in the upper parts of the stem must be due to the nutrition being more abundant. All this still fails to explain the *sudden* stimulus to the annual rings in the lowermost parts of suddenly isolated trees, and Hartig suggests that the probable cause is an increased supply of potassium salts and phosphates, rendered available at the roots. This of course implies the further assumption that such minerals are employed directly, and however probable this may be, it is by no means proved.

The removal of branches from the tree leads to the same results as crowding, *i.e.* the rings formed below are thinner, because the supplies are not sufficient to feed the sheet of cambium equally from above downwards. Moreover, the complementary case may occur: a tree in the open may have *too many leaves*, as is proved by the fact that it may be pruned without any loss of increment. The leaf-area of a tree is by no means always proportional to the supplies of food-materials from the soil: it may be too large or too small to be working economically, or so large that each leaf is sluggish—lazy, so to speak, and not doing anything like the amount of work it is capable of. Not only is this idea interesting and suggestive in itself, but it has important bearings on the question of the thinning and treatment of forests generally.

We must leave this topic, however, and pass to one of a different nature, but no less scientifically important. This is the weight of the wood. Although certain practical ends can be roughly attained by merely weighing equal-sized blocks of any particular kind of timber, at any time or in any state, it is, nevertheless, easy to see that such

[1] Hartig has since proved that this explanation is the correct one (*Botanische Zeitung*, December 28, 1888, p. 837).

weighings are of little or no scientific value: only the weight of the fresh timber immediately it is felled, and the absolute dry weight (after exposure to 105° C. long enough to drive off all moisture) yield results of really scientific value.

If we regard 1 cubic metre as the unit of volume, we may obtain some useful factors by ascertaining the weight of dry woody substance in such a volume, from different parts of the tree, and from trees grown under different conditions, &c. The amount of water driven off, *i.e.* the difference between the fresh weight and the absolute dry weight, is found to vary much, and Hartig some time ago obtained most valuable results, bearing on the difficult question of the ascent of water in tall trees, by comparisons of this kind. Moreover, the real test of quality of wood—its value as fuel, and other technical properties—is given in the absolute dry weight.

Passing over the methods, and other details, it may next be pointed out that the weight of a given volume of wood depends chiefly on the sizes and distribution of the histological elements—vessels, tracheides, fibres, &c.—and in the case of beech-wood, it is especially the sizes and numbers of the vessels that have to be taken into account, and as these stand in direct relation with the magnitude of transpiration, it is clear that the quality of the timber as estimated by its weight depends on the quantity of leaves.

Neglecting the roots, we may regard the tree as consisting of three parts: the stock, the shaft, and the crown. Now, the root-stock and the crown contain wood of the best quality, and some curious results come out on examining why this is.

As is well known, the base of the tree widens at the origins of the main roots, and here the annual rings are broadest: if we bear in mind that the number of vessels in each annual ring remains constant, it is easy to understand why the wood is better—it is simply that the vessels are dispersed over a larger sectional area, and are separated by more numerous fibres, the elements which give solidity to the wood.

We have seen that in the trunk of a tree with a large crown of leaves, the mass increment increases from above downwards: this means that the same number of vessels (per annual ring) are distributed over a smaller sectional area above. In a given case, on 1 square millimetre of area, there were 115 vessels at a height of 1·3 metre, but at 10·7 metres height there were 175 vessels on the same area; hence the latter was lighter and worse wood.

By thus counting the number of vessels per square millimetre, and taking the average size of the main vessels, it was possible to get an expression of the relative area occupied by the lumina, and that of the rest of the annual ring; of course this is only approximate.

It comes out that, in trees with large crowns, while the number of vessels is the same at all heights in the stem, the number of vessels *per square millimetre* is much fewer below than above.

In the crown of the tree, however, things are very different; the number of vessels in each annual ring rapidly diminishes, because at each branching a number are given off. Thus, where 200,000 vessels were found in an annual ring in the stem, the same in the crown gave only 57,750. This alone would explain the better quality of the wood, but the number of vessels per square millimetre is also found to *increase* in the crown, and this means corresponding depreciation. But the most important factor in explaining the superior hardness, &c., of the wood in the branches is that the average size of the vessels is less, and therefore the area of lumina in the cross-section is reduced.

Physiologically, the reduction in the lumina of the vessels is in relation with the decrease in the volume of water-current as we ascend, and several facts point to the constancy of this relation. It is well known that, if the soil around a tree is suddenly deprived of much of its water, the tips of the tree die off first: "stag-headed" trees are often produced by over-exposure. This is because the average size of the vessels has been adapted for a richer supply of water than comes to them under the new conditions. Hartig says that the average size of the vessels throughout is reduced if the land is deprived of cover, and the tree exposed too much.

As has been seen, the wood of trees below 60 years of age contains fewer vessels, and these with smaller lumina, than afterwards. It is also known that the ascending water-current is confined to the younger outer wood, or alburnum; and if we neglect younger trees, it seems that in the beech it is only the 20 or 30 outer annual rings which conduct the water.

Now the authors of the book referred to find an unexpected relation between the amount of wood produced annually, and the current of water passing up the stem. By an ingenious series of measurements and calculations, it results that much more room is provided for the water-flow in early years than in old age. Thus, a given amount of water, which has for its passage in a tree 30 years old an area of wood expressed by the number 4·04, has only an area equal to 1·64 at 140 years of age. Hence, in order to conduct the larger quantities of water which must pass to the larger crown, the smaller area of wood, in the older tree, has to *increase the number and size of its vessels*, and so the wood is lighter and poorer.

It is impossible here to enter into the bearing of these matters on questions of forest management; it is only a particular case of the dependence of technical forestry throughout on the teachings of science, the principles of which it applies.

An interesting experiment may be quoted. Two beeches 150 years old were felled and examined; they had been completely freed from neighbouring trees 7 years previously. The effect of the sudden exposure to free light, air, &c., was that the mass increment rose to 2·4 times greater than previously, and the weight of the wood formed during the 7 years of exposure was 700 kilogrammes per unit volume, as against 600 kilogrammes previously, *i.e.* 16·7 per cent. more wood-substance was formed. On going into details, it was found that *five times as much wood-substance* was formed each year, and *twice as many vessels* were developed in each annual ring. But since these twice as many vessels were distributed over five times the quantity of wood, the wood was still heavier than that of 7 years previously. On the square millimetre there were 63 vessels, as contrasted with 140.

The reason that letting in the light and air around the tree has such enormous effects is obvious enough to the physiological botanist, but it should also be clear that the knowledge thus obtained is the best guide to such forest practices as thinning and freeing timber: into these matters, however, we do not propose to enter further here, but must pass to other matters. In the section on the course of growth of the beech, an interesting discussion on the limits of height of trees occurs: Hartig regards the chief limiting cause to be the gradual disappearance of the difference in tension between the air-bubbles in contiguous elements: the osmotic forces remain constant throughout, but the lifting power diminishes with age and height, until it ceases to suffice for movement. The influences of etiolation, and judicious crowding, and other devices for timber-growing, are then discussed in the light of what has been already said, and with the aid of numerous tables of close-set and well-classified figures, sufficient illustrations are given to satisfy the most stiff-necked critic of the value of these results.

The chemist's results, however dry they may appear from the tables and curve-diagrams, allow of summary in a way that endows them with an interest to the general reader, no less real than that which attaches to other parts of the work. Methods may be passed over here.

The cortex of course contains most ash, and the quantity of total ash increases with age and with height: these facts have been shown for other trees also.

In the wood proper, the quantity of ash *as a whole* increases from the periphery to the centre, but as we shall see that the distribution of the various constituents is very different in different parts, this generalization will have to be cut up into a series of less general statements. In the same period of growth the total ash increases with the height.

It is somewhat striking that the inner zones of the inner alburnum yield most ash, and thus the central part of the highest transverse section of the stem will contain most ash.

As regards the changes due to age, the ash per cent. decreases till the tree is about 60 years old, and then it increases rapidly for twenty years or so, gradually diminishing again with increasing age. These periods show such close relation to certain facts in the culture of the trees, that they are evidently explained somewhat as follows. During the first 60 years in the plantation, the young beeches crowd one another more and more, and the competing roots restrict one another, and the percentage amount of salts absorbed diminishes year by year: at or about the age of 60 years the trees are thinned by systematic felling, and so more space is given to those which remain, as well as more soil and ingredients from the decomposition of the roots, &c., of the felled trees. The consequence is the increase of ash to a first maximum. At the period about 80 to 90 years the beech has attained the seed-bearing age, and the probability that the diminution of ash henceforth is due to the drain to supply the seeds is too great to be overlooked.

It is interesting to note that shaded beeches, at all periods and in all parts, show a higher percentage of total ash than fully exposed trees, and the same is true of the silver fir (another tree which bears much shading): the trees store up mineral substances, which must be an advantage to them under the circumstances of growth.

If, instead of regarding the total ash, we now look at the constituents, it results that the enormous excess of ash in the cortex consists chiefly of calcium carbonate, from the calcium oxalate (which may form 70 to 90 per cent. of the whole). Much potash, magnesia, and phosphoric acid also occur.

In the wood, the quantity of potassium salts increases from the periphery to the centre; whereas the reverse is the case with the phosphoric acid, sulphur, and magnesia, a fact the more remarkable because the potash usually accompanies the phosphoric acid in other parts of plants —*e.g.* in leaves, &c. It is no accident, however, and the fact comes out that the beech forms large reserve stores of potash (this being the chief cause of the large increase of total ash in the interior of the stem), whereas the phosphoric acid and sulphur travel outwards with the proteids, being repeatedly used in metabolism in the cambium, &c.

We must pass over a number of other peculiarities of the distribution of the ash-constituents, to notice the effect of the age of the tree on the chief salts. The distribution of the potash, lime, and magnesia is little influenced by age, but an extraordinary effect comes out in the case of the phosphoric acid. The young tree starts with a relatively large quantity of this constituent, but the amount sinks year by year till the fiftieth or sixtieth year, and then rises again to about the ninetieth year, to fall afterwards: in fact, the behaviour is similar to what occurs with the total ash, and is doubtless to be referred to the same causes.

Another curious result comes out in studying shaded trees: whereas they take up as much potash and lime as exposed trees, their magnesia and phosphoric acid fall far below those of exposed trees. But the most astonishing discovery is that shaded trees *take up four times as much sulphur* as exposed ones. The analyst himself notes how astounding this is, but he insists that a second series of analyses gave confirmatory results.

Another queer fact is that the kind of soil exerts little influence on the analyses; though a similar conclusion has been come to with other plants.

The study of the absolute quantities of individual ash-constituents in 1000 parts of the dry substance brings out some interesting and important generalizations, which are expressed in the form of curves, and fully bear out in detail what has already been stated.

The quantity of ash and of each ash-constitutent in 1 cubic metre of beech-wood at various ages, as compared with the wood of other trees, is next investigated. The results show that the beech takes more potash than most trees except the *Robinia*—for instance, at 40 years it contains more than four times as much as the spruce fir.

As regards phosphoric acid, the beech and oak need more than other trees, beech-wood at 40 years old having seven times as much as spruce at the same age. With lime the facts are similar: beech needs much more than conifers.

From the whole of the preceding, it is possible to put together some ideas on the quantity of ash-constituents per acre needed for beech forests, and some interesting tables and curves are given in this connection; the return of minerals to the soil in the leaf-fall, &c., is also considered. Perhaps the most important conclusion come to here is that the increment in dry weight of the tree is nearly proportional to the up-take of potash, whereas the up-take of lime is the same—gradually increasing to old age—whether the wood is good or bad, and whatever the nature of the soil. The nitrogenous substance in beech-wood behaves very like the phosphoric acid, in that it diminishes from the tenth to the sixtieth year, and then ascends to a second maximum as the tree reaches 80 years old; and again, the cause is to be found in the influence of the thinning, and in the demands on the reserves when the tree begins to bear seed.

As in all trees, there is of course most nitrogen in the twigs and buds, and in the finer roots. Beech and oak need more nitrogen than other trees, and (so far as the wood goes) the conifers need much less. The total quantity of nitrogen taken up by the beech at 6 years old, in fully stocked plantations, is calculated to be 39·43 kilogrammes per hectare, and this rises to 389·63 at 60 years, and 896·50 at 130 years.

Calculations as to the quantity of nitrogen needed annually per hectare to produce the known yield of wood are then given, and again we meet with the rapid loss after about 90 years, due to seed-production. To these are added estimates of the nitrogen removed in the thinnings, and of that restored in the fallen leaves. All things considered, the quantity of nitrogen concerned annually varies with the age, but at the critical period of 50 to 100 years it amounts to something like 60 kilogrammes per hectare *per annum*.

It is unnecessary to point out further the extreme importance of such investigations as these: it is only in proportion as a nation is armed with statistics based on careful researches like these that it can form any conclusions worth having as to the future value of its forests and the technical merits of those administering them. As to their "practical" bearings, the results speak for themselves: if this is not allowed to be practical science, we may indeed ignore the cry.

H. MARSHALL WARD.

SPECTROSCOPIC RESEARCHES AT THE NORWEGIAN POLAR STATION.

PART II. of the Report on the results obtained at the Norwegian Polar Station at Bossekop in Alten (in connection with the International Polar Investigation, 1882–83) was recently issued at Christiania; and we have already said something as to the contents (NATURE, December 13, 1888, p. 155). The following is a translation of a statement, by Herr Cand. C. Krafft, in this Report:—

"For spectroscopic researches the Expedition took with them a Wrede spectroscope. Unfortunately the obligatory observations did not render it possible to devote adequate attention to spectroscopic researches. The writer may also specially note that the use of powerful magnifiers made measurements with the above-mentioned apparatus extremely fatiguing, and often quite impossible. It seemed to me all the more permissible to omit these measurements because the situation of the usual aurora-line is often very distinctly defined. Other lines besides these were only sometimes observed. Weak, indeterminable bands I observed on November 12, 4h. 18m. If I remember rightly, I saw similar indeterminable bands on another occasion, but I cannot find any notice of it in the observations. The red line was sometimes remarked, but it showed itself very conspicously, and flashed up only some moments (November 2, 9h. 15m.; November 17, 4h.). The general rule is that only the aurora-line was to be seen even in strong auroræ; as, for example, on November 2, 8h. 55m., during a crown-formation, and on November 5, 8h.–9h. on a bow with the intensity 2–3.

"In order to find the value of the scale-division of the spectroscope expressed in wave-lengths, I made, on October 30, 1882, the following determination of the most important Fraunhofer lines:—

B ...	25·04 ($\lambda = 6867$)	*a* ...	23·27 ($\lambda = 6276$)
C ...	24·16 ($\lambda = 6562$)	D (Mean)	21·78 ($\lambda = 5892$)
E ...	18·51 ($\lambda = 5269$)		
b (Mean)	17·84 ($\lambda = 5174$)		

"With the help of these determinations I constructed a curve, and obtained from it the following wave-lengths of the auroral lines:—

November 2, 8h. 55m. aurora-line (mean) 20·37 ... $\lambda = 5595$
November 11, 10h. 15m. aurora-line 20·26 ... ... $\lambda = 5586$
[D (NaCl flame) 21·71.]

"November 17, 4h. 20m.; Herr Schroeter found the following values:—

Aurora-line 20·37, 31, 34, 34 } Mean 20·34 ... $\lambda = 5587$
Red line 23·00 ... $\lambda = 6205$.

"On account of the rapid flashing-up and disappearance of the red line only this one measurement could be obtained.

"The spectroscope was used chiefly to decide occasionally, in doubtful cases, whether and how far the aurora was present—a matter which, as is well known, it is very often impossible to decide in any other way. Fine cirrostratus clouds may so closely resemble the aurora as to be taken for it, especially if they are lighted by the moon or by twilight. In the latter case one may recognize the aurora-line apart from the continuous spectrum (January 15, 12h.; March 29, 14h.). Meanwhile I do not think I can decide whether the aurora line is to be regarded as absolute criterion for the aurora; I have had an opportunity of observing pulsating masses of light (December 18, 9h.), and also otherwise inexplicable phenomena of light, as well with the usual aurora colour (January 13, 10h.) as with red (November 17, 6h. 15m.), without being able to discover the aurora-line. On a red mass of light it might appear very weakly, even if the light-mass shone powerfully (November 17, 16h.). Beside, the aurora-line was very often to be recognized everywhere. This sometimes made me think that the whole firmament was covered with aurora material, although the explanation may be that the line everywhere visible springs from an aurora, only slightly extended, reflected from fine clouds, &c., floating in the air. This reflected light showed the aurora-line even on objects on the earth (snow on a field, a wall), and even when the sky was pretty well covered (November 11, 10h.; November 12, 5h.; November 14, 8h.; December 15, 15h. 25m.; December 16, 9h.)."

NOTES.

THE Croonian Lecture of the Royal Society, which, as we have already announced, is to be delivered this year by M. Roux, the "Chef de Service" of the Pasteur Laboratory, has now been fixed for Thursday, May 23, at 4.30 p.m., in the Royal Society's apartments at Burlington House.

A GOOD many arrangements for the Newcastle meeting of the British Association, over which Prof. Flower will preside, have now been made. Among the Vice-Presidents are the Duke of Northumberland, the Earl of Durham, the Bishop of Newcastle, Lord Armstrong, the Mayors of Newcastle and of Gateshead, and Mr. John Morley. The following are the Presidents of the various Sections:—A—Mathematical and Physical Science, Captain W. de W. Abney, 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, Colonel Sir Francis de Winton. F—Economic Science and Statistics, Prof. F. Y. Edgeworth. G—Mechanical Science, Mr. William Anderson. H—Anthropology, Prof. Sir W. Turner, F.R.S. The first general meeting will be held on Wednesday, September 11, at 8 p.m. On Thursday evening, September 12, there will be a *soirée*; on Friday evening, September 13, a discourse on "The Hardening and Tempering of Steel," by Prof. Roberts-Austen, F.R.S.; on Monday evening, September 16, another discourse; and on Tuesday evening, September 17, a *soirée*. Excursions to places of interest in the neighbourhood of Newcastle-on-Tyne are being arranged for Saturday, September 14, and Thursday, September 19.

AT a recent meeting of the Executive Council of the British Section of the Paris Exhibition, the cordial thanks of the Council were given to Sir Frederick Leighton, P.R.A., and the Fine Arts Committee, for their exertions to insure that the Fine Arts Department at the Exhibition should be a credit to the British Section and the country. The result of the exertions of the Committee will be that British art will be represented in Paris by works of many of our foremost artists. Why is not like energy being displayed by English men of science? There ought to be a Science as well as a Fine Arts Committee, and the necessary arrangements might easily be made, as there are several members of the French Institute in England.

THE Directors of the Ben Nevis Observatory have applied to the Association of the Glasgow International Exhibition of 1888 for a grant from the surplus fund of the Exhibition. In the memorial setting forth the claims of the Observatory on the support of the public and of public bodies, reference is made to the immediate and important advantages that will result from the work of the High and Low Level Observatories of Ben Nevis towards the further development of the meteorology of the Clyde, in which Glasgow has taken so prominent a part, and by the results of which the shipping and commercial interests will to a certainty be largely benefited; and it is urged that, in carrying out these national objects, the Directors must look to the liberality of the public and of public bodies, for the assistance required to supplement the aid offered by the Government towards the completion and maintenance of this double Observatory.

THE Botanical Society of France has issued a circular signed by its President, M. de Vilmorin, and Secretaries, inviting foreign botanists to attend a Botanical Congress to be held in Paris during the second half of August in the present year, and to present treatises on botanical subjects, pure or applied, that may be most familiar to them, with the view of promoting discussion on them. The following subjects are especially proposed for consideration:—(1) The usefulness of establishing joint action between the different Botanical Societies and Museums for the purpose of preparing accurate maps of the distribution of species and genera of plants over the globe, a work similar to that undertaken by International Geological Congresses. An Exhibition of maps, books, *brochures*, photographs, &c., relating to botanical geography will be held, during the Congress, at its place of meeting. (2) Characters for classification furnished by anatomy. Botanists intending to be present at the Congress should send in their names, before June 1, to M. P. Maury, the Secretary of the Organizing Committee, 84 Rue de Grenelle, Paris, when they will receive special invitations, and information as to the day and place of meeting. The titles of papers proposed to be read, or of verbal communications, should be forwarded as early as possible.

We reprint from the *Times* of March 26 the following obituary notice:—"We have to record the death, at a ripe age, of a man whose name is well known and honoured wherever the science of naval architecture is studied. Joseph Woolley, M.A., LL.D., F.R.A.S., formerly Principal of the School of Mathematics and Naval Construction at Portsmouth, and subsequently, for many years, the Admiralty Director of Education, died at Sevenoaks on Sunday, after a few days' illness. Trained at Cambridge, where he was a Fellow of St. John's College, he was selected in 1848 as the head of the Technical School founded in that year by the Admiralty. He continued to hold that office until the school was discontinued in 1853. When a School of Naval Architecture was again founded, on other lines, at South Kensington, in 1864, Dr. Woolley was appointed Inspector-General by the Committee of Council on Education, and he continued to superintend the school until his retirement from active life. In 1850 he published a "Treatise on Descriptive Geometry," which is widely known as a text-book. In 1860, when the Institution of Naval Architects was founded, very largely by his own personal influence, Dr. Woolley opened its proceedings by an address on "The present state of the mathematical theory of naval architecture." He enriched the Transactions of the Institution with frequent contributions on all current questions presenting any peculiar difficulty. He was a member of the Committee on Designs in 1871, and of other important Naval Committees. He was for many years in holy orders, but he relinquished them later in life, although he continued to be to the last a devout worshipper in the Church of England. He was a man who was much loved by all who were privileged to work with him."

We regret to learn that Prof. Donders died at Utrecht on Sunday.

Two physiologists of note have recently died: Prof. Krukenberg, of Jena, well known for his researches in invertebrate physiology, and R. Gscheideln, of Breslau, the author of a "Physiologische Methodik," which unfortunately remains unfinished.

We learn from *Science* that Captain John Ericsson, whose death, at New York, we lately recorded, continued to labour at his sun-motor until within two weeks of his death. "As he saw his end approaching, he expressed regret only because he could not live to give this invention to the world in completed form. It occupied his thoughts up to his last hour. While he could hardly speak above a whisper, he drew his chief engineer's face close to his own, gave him final instructions for continuing the work on the machine, and exacted a promise that the work should go on." *Science* says that the respect shown at Captain Ericsson's funeral was such as is seldom seen at that of a private citizen. "The streets in the neighbourhood of his late residence were crowded from the early morning hours with thousands, who for four hours passed through the house to pay homage to the departed genius. New York is a place full of human beings,—so full that each pays little or no heed to his neighbour; yet the great respect for this man of science and of action was shown in the number and character of those who followed his remains to their resting-place, in the uncovered heads as they were borne along the busy streets, and in the impossibility of admitting to Trinity all that wished. Ericsson was a man who could have endeared many to him, but he had a strong sense of duty to his work, which induced him to make few friends. This final homage of the unmindful crowds of the great city was to his genius well applied."

A gift of some scientific as well as artistic interest has just been made to the Royal Hibernian Academy, Dublin, by Miss Mary Anne Nicholl. She has presented to the Academy fifty-six studies in water-colours of the palms and foilage plants and fruits of Ceylon, painted by her late father, Andrew Nicholl, R.H.A., who held the first appointment of Master of Landscape Painting, Engineering, Drawing, and Design, in the Colombo Academy. The studies are accompanied with a list of the names of the flora.

At the distribution of prizes to students of the Polytechnic Institute, Regent Street, on Monday, Mr. W. T. Paton was able to give a good account of the past year's work. The number over and above the usual attendance had been, he said considerably more than 1000, and they now had 7000 members, who were attending classes there. The Lord Mayor, who gave away the prizes, spoke of the advance which had lately been made in technical education, and of the good influence exerted by the Polytechnic Institute. The Committee wished him to say that they had now annexed the West End School of Art to the Institute. Further funds would be required to carry on the work. The Charity Commissioners would provide £31,000 for endowment if another £4000 were forthcoming.

The Geographical Society of Bremen has commissioned Dr. Kückenthal, of Jena, to undertake another journey to the Arctic regions, in order to make zoological researches. He will start for Spitzbergen at the end of April, and is expected to return in October next.

Prof. Franz Exner, of Vienna, who has spent some months in Ceylon studying atmospheric electricity there, is now on his way back to Europe. A grant was made by the Vienna Academy of Sciences in aid of his scientific work.

The new Natural History Museum at Vienna will be opened to the public in the summer, and it is expected that the rich collections will attract large numbers of visitors.

Dr. J. Hann, Director of the Austrian Meteorological Service, has laid before the Vienna Academy of Sciences an exhaustive investigation of the diurnal range of the barometer over the globe. He has calculated the harmonic coefficients for each month, and for the year, for a large number of places, and has investigated the variation both of the phases and of the amplitudes of the single and double daily oscillations. The latter show a remarkable independence of geographical and seasonal influence (as before pointed out by Lamont and others), and appear to be connected with a cosmical origin. The investigation also shows that the amplitudes of the semi-diurnal oscillation decrease with height in exact proportion to the pressure, and have a marked dependence upon latitude. The yearly range exhibits two maxima at the periods of the equinoxes, and also a third maximum which falls in January in both hemispheres, while in July the amplitude of the double daily oscillation is smallest over the whole globe. The author also investigates the single daily oscillation, in connection with the influence exerted by the position of the station, as well as the range of the barometer at sea, and arrives at some interesting results.

SIX shocks of earthquake were noticed at Aquila on March 11. Two were very severe, but had no injurious results. Shocks were felt at Idstein, Auroff, and Görsrod, near Wiesbaden, on March 12, at 2.29 a.m. The direction of the shocks was from west to east.

TELEGRAMS received at Madrid report that a strong shock of earthquake was felt on March 25 at Alhama in the province of Granada. No damage was done, but great alarm prevailed among the inhabitants.

M. B. HASSELBERG, of Pulkowa, has been studying the absorption spectrum of iodine, which he has succeeded in resolving into widely separated lines with a Rowland grating, and in photographing. The wave-lengths of about 3000 lines have been determined by a dividing-engine.

ANOTHER interesting pair of geometrical isomers have been discovered by Dr. Auwers and Prof. Victor Meyer. They are the monoxims of benzil, both possessing the constitution $C_6H_5 . C(NOH) . CO . C_6H_5$. Benzil, $C_6H_5 . CO . CO . C_6H_5$, is the typical di-ketone of the benzene series, and reacts, like other ketones, with hydroxylamine. As there are two CO groups present, there are two possible oxims, a monoxim and a dioxim. A few months ago, Dr. Auwers and Prof. Meyer showed that there were really two dioxims, both of the constitution $C_6H_5 . C(NOH) . C(NOH) C_6H_5$, but differing in the arrangement of the various groups in space. One of these isomers was shown to probably possess the configuration

$$\begin{array}{l} C_6H_5—C=NOH \\ \quad\quad\quad\;\; | \\ C_6H_5—C=NOH \end{array}$$

while the other, which melts 30° C. lower than the first, may be formulated

$$\begin{array}{l} \quad\;\; C_6H_5—C=NOH \\ \quad\quad\quad\quad\quad\;\; | \\ NOH=C—C_6H_5 \end{array}$$

It is now found that there are also two corresponding monoxims, one of which, termed the α-monoxim, may be represented as

$$\begin{array}{l} C_6H_5—C=NOH \\ \quad\quad\quad\;\; | \\ C_6H_5—C=O \end{array}$$

while the β-monoxim has its groups probably disposed in the manner

$$\begin{array}{l} C_6H_5—C=NOH \\ \quad\quad\quad\;\; | \\ \;\; O=C—C_6H_5 \end{array}$$

Both these monoxims are obtained when benzil and hydroxylamine, NH_2OH, are allowed to react upon each other at the ordinary temperature. If the hydroxylamine be used in the form of its hydrochloride dissolved in a little water and added to an alcoholic solution of the benzil, a preponderating quantity of the β-compound is formed, and in greater quantity the higher the temperature. At − 15° C., the product consists largely of the α-monoxim; at 0°, about equal quantities of the two are formed; at the ordinary temperature of a room the product is almost exclusively of the β-compound; and finally, when the operation is conducted upon a water-bath, a quantitative yield of the β-monoxim is obtained. The α compound is best prepared by dissolving 10 parts of benzil in 30 parts ordinary alcohol, and adding a mixture of 3½ parts of hydrochloride of hydroxylamine and 4 parts of soda dissolved in a little water. After standing a few hours the mixture is poured into water, and the turbid liquid thus formed filtered. On acidifying the filtrate an oil separates out which rapidly crystallizes. On recrystallizing the mixed crystals from dilute alcohol, a large yield of the pure α-compound is obtained, owing to its much more sparing solubility, in microscopic tabular four-sided crystals possessing a mother-of-pearl lustre. It may also be recrystallized from benzol, from which it is obtained in the same form. The crystals melt sharply at 137°. On the other hand, the β-monoxim crystallizes from alcohol in thick prisms, melting at 113°, 24° lower than the α-compound. Another striking point of dissimilarity is that from benzol the β-compound crystallizes with half a molecule of benzol of crystallization. Each reacts with a further equivalent of hydroxylamine to form the corresponding dioxim; and each also forms a characteristic ethereal salt with acetic acid, the α-acetic ether forming broad flat prisms melting at 61°, and the β-acetate crystallizing in needles of melting-point 78°. Hence the oxims of benzil form a most beautiful and indubitable case of true geometrical isomerism, and a valuable further justification of the modified Van t' Hoff-Wislicenus hypothesis. It is to be hoped that, by further investigations of similar cases, we may indeed eventually be enabled to form some idea of the actual orientation of the atoms in our chemical molecules.

THE American Society of Naturalists recently appointed a Committee to report on the teaching of science in schools. The Report, which has been adopted and approved of by the Society, contains, amongst others, the following suggestions as to the mode in which, in the opinion of the Committee, science can best be taught in the schools:—Instruction in natural science should begin in the lowest grades, where it should be conducted chiefly by means of object-lessons. More systematic instruction should be given in the high schools during the four years' course preparatory to College. An elementary knowledge of some one or more branches of natural science should be required of every candidate for matriculation at College. There are some differences of opinion as to the details in carrying out this plan, but the Committee recommends that scientific study should begin with the study of plants and animals, the botanical instruction beginning with drawing the outlines of the leaves of plants, and the zoological with descriptions of the more familiar animals, special prominence being given to the study of those plants and animals which are useful to man. The simple geological phenomena of the district in which the school is situated should be taught. Children should be encouraged to collect specimens of all kinds of natural objects, and these specimens could be made the subject of the object-lessons. An attempt should be made to teach the rudiments of human physiology and hygiene. The Committee recommends the introduction into the highest grades of the grammar school of very rudimentary lessons in physics and chemistry, which would pave the way for further study in the high schools and Colleges.

WE have received several interesting papers, by Prince Roland Bonaparte, on subjects relating to geography and anthropology. One of them (in French) is an account of the early voyages of Dutchmen to the East India Archipelago. In another series of French papers the Prince deals with geographical discoveries in New Guinea. He has also reprinted from the Journal of the Anthropological Institute a note (in English) on the Lapps of Finmark. In this paper he presents various anthropological data collected during a tour of three months in Scandinavia. A more elaborate paper (in French), by F. Escard, which is printed in the same form as these essays, gives a full account of the experiences of Prince Roland and his companions in the country of the Lapps.

THE "Record of the Excursions of the Geologists' Association, 1860-84," which has been prepared by Mr. T. V. Holmes, is now ready for the press, but it will not be printed until the names of a sufficient number of subscribers have been received. The work will consist of over 500 pages, and contain accounts of all the sections and districts visited by the Association down to the end of 1884, with the illustrations (sections, &c.), which have from time to time appeared in the circulars and Proceedings.

A FRENCH translation of Prof. Romanes's "Mental Evolution in Man" is in course of preparation in Paris.

THE *Oesterreichische Botanische Zeitschrift*, now in its thirty-ninth year, is edited, from the commencement of the present year, by Dr. Richard R. von Wettstein.

AT the annual meeting of the Governors of Aberdare Hall, University College, Cardiff, which took place this month, the Executive Committee were able to submit a most satisfactory report. Several students had distinguished themselves by gaining scholarships both at the College and Hall; two had taken the B.A. degree (London); others had passed the Intermediate in Arts and matriculation examinations, among whom was Miss Moss, who took the twelfth place in Honours division, matriculation examination.

THE additions to the Zoological Society's Gardens during the past week include two Chinese Mynahs (*Acridotheres cristatellus*) from China, presented by Mrs. Rigby; a Rose-crested Cockatoo (*Cacatua moluccensis*) from Moluccas, presented by Miss Liming; a Long-tailed Copsychus (*Copsychus macrurus*, ♂) from India, two Silky Bower-Birds (*Ptilonorhynchus violaceus*, ♂ ♀) from Australia, a Blue and Yellow Macaw (*Ara ararauna*) from South America, deposited; two Squirrel Monkeys (*Chrysothrix sciurea*) from Guiana, a Four-horned Antelope (*Tetraceros quadricornis*, ♂) from India, a South American Flamingo (*Phœnicopterus ignipalliatus*) from South America, purchased; a Gayal (*Bibos frontalis*, ♀), a Vulpine Phalanger (*Phalangista vulpina*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBSERVATIONS OF JUPITER.—An excellent series of eighty-four drawings of the planet Jupiter at different periods during the years 1881–86, made with the reflector of 3 feet aperture at Birr Castle Observatory by Dr. Boeddicker, has just been published in the form of a communication to the Royal Dublin Society (vol. iv. series 2, March 1889). Twenty-two of the drawings were made during the opposition of 1881–82, thirty-one during 1882–83, twenty-one during 1883–84, eight during 1884–85, and two during 1885–86. The drawings made at the telescope have been exactly reproduced by a photo-mechanical process in order to avoid the errors which might have arisen by the employment of the ordinary lithographic process. Throughout the descriptive notes a very convenient notation has been employed for reference to the various features. Dr. Boeddicker draws attention to the three observations of March 16, 1883, showing remarkable changes in the appearance of one of the belts during the course of an hour. The first drawing shows two detached patches, which, in the succeeding drawings, become the shadows of large cumulus-like clouds lying across the Jovian surface. It is suggested that these apparent changes may be simply due to the combination of the more obvious details with the finer ones after prolonged examination, and that the discrepancies between drawings made at the same time by different observers may thus be accounted for. Photography may be expected in the near future to overcome this difficulty.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *MARCH* 31—*APRIL* 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 March 31

Sun rises, 5h. 38m.; souths, 12h. 4m. 8·2s.; sets, 18h. 30m.: right asc. on meridian, 0h. 40·3m.; decl. 4° 21′ N. Sidereal Time at Sunset, 7h. 7m.

Moon (New on March 31, 12h.) rises, 6h. 12m.; souths, 12h. 13m.; sets, 18h. 28m.: right asc. on meridian, 0h. 49·2m.; decl. 0° 7′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	5 17 ...	10 47 ...	16 17 ...	23 23·3 ...	6 35 S.
Venus.....	6 4 ...	14 16 ...	22 28 ...	2 52·9 ...	22 52 N.
Mars	6 16 ...	13 22 ...	20 28 ...	1 58·3 ...	12 1 N.
Jupiter....	2 1 ...	5 57 ...	9 53 ...	18 31·9 ...	22 57 S.
Saturn....	12 49 ...	20 28 ...	4 7*...	9 5·7 ...	17 53 N.
Uranus ...	19 16*...	0 42 ...	6 8 ...	13 16·3 ...	7 21 S.
Neptune..	7 33 ...	15 17 ..	23 1 ...	3 53·7 ...	18 37 N.

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

April.	h.	
2 ...	2 ...	Mars in conjunction with and 5° 7′ north of the Moon.
3 ...	5 ...	Venus in conjunction with and 11° 7′ north of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5 ...	81 17 N. ...	Apr. 1,	4 15	*m*
			,, 6,	3 55	*m*
Algol	3 1·0 ...	40 32 N. ...	Mar. 31,	19 50	*m*
ζ Geminorum ...	6 57·5 ...	20 44 N. ...	Apr. 4,	1 0	*M*
R Canis Minoris ...	7 2·6 ...	10 12 N. ...	,, 5,		*m*
R Canis Majoris ...	7 14·5 ...	16 11 S. ...	,, 5,	19 47	*m*
		and at intervals of		27 16	
U Monocerotis ...	7 25·5 ...	9 33 S. ...	Apr. 6,		*M*
U Geminorum ...	7 48·5 ...	22 18 N. ...	,, 6,		*M*
W Virginis	13 20·3 ...	2 48 S. ...	,, 2,	1 0	*m*
X Boötis	14 18·9 ...	16 50 N. ...	,, 1,		*M*
δ Libræ	14 55·1 ...	8 5 S. ...	,, 2,	2 0	*m*
U Coronæ	15 13·7 ...	32 3 N. ...	,, 4,	4 30	*m*
β Lyræ...	18 46·0 ...	33 14 N. ...	,, 3,	0 0	m_2
R Lyræ	18 52·0 ...	43 48 N. ...	,, 5,		*m*
δ Cephei	22 25·0 ...	57 51 N. ...	,, 2,	23 0	*M*

M signifies maximum; *m* minimum; m_2 secondary minimum.

Meteor-Showers.

	R.A.	Decl.	
Near γ Libræ	233° ...	15° S. ...	Swift; long paths.
From Delphinus	305 ...	12 N. ...	Slow; bright.

GEOGRAPHICAL NOTES.

AT the meeting of the Geographical Society on Monday two papers were read, both dealing with the Caucasus, midway between Kazbek and Elburz. Here the chain towers up in two great parallel crests, containing within a few square miles at least half a dozen peaks over 16,000 feet in height, an elevation probably reached nowhere else by the summits of the crystalline crest. Two of these peaks are recognized as the second and third summits of the Caucasus—Koshtantau, 17,091 feet; and Dychtau, 16,924 feet. One of the papers, by Mr. A. F. Mummery, described his ascent last summer of Koshtantau, while Mr. H. W. Holder dealt with the peaks of the neighbouring Bezingi Glacier. From Mujal, on the south-west of the Zanner Glacier, Mr. Mummery and his companion made their way round by the Thuber and Gvalda passes to Bezingi in order to make the ascent from that side. The arrangement of this part of the chain, Mr. Mummery states, is, from an Alpine point of view, very curious. There is a lofty ridge with occasional *aiguilles*, from the southern slopes of which stretch the great ice-fields of the Thuber, and there is a second and rather less lofty ridge to the north and parallel to it, from the northern flank of which flow the Basil-su and its various affluents. In the narrow trough between these two ridges lies the head of the Gvalda Glacier. Though seldom so clearly marked as in this instance, the same system of short parallel ridges may be traced throughout the whole central group, with the result that the upper and middle basins of the great glaciers are nearly always parallel to the main ridges, and it is only when the drainage from these catchment basins reaches the head of the lateral valleys that the ice sweeps round and flows away at right angles from the watershed. The Gvalda Glacier is probably the most important on the south side of the Caucasus, and far exceeds in size any on the south slope of the Alps. Its basin probably exceeds in extent that of the Glacier du Géant, to which it is not without a resemblance. The Caucasian glaciers in this part of the chain are much less crevassed than the Alpine, apparently due to the lesser inclination of the great glaciers, and possibly to the greater thickness of their ice. With reference to Caucasian forests, Mr. Mummery has some interesting observations. The upper valley of the Basil-su can still boast a fairly extensive forest; but partly by the axe, and mainly by the agency of the sheep and goats, the forests are fast shrinking. Below a certain point in the Basil-su Valley, not a tree, not a bush is to be seen; the country has been denuded by the flocks of the natives. Mr. Mummery is inclined to attribute the extraordinary contrast between the treelessness of the northern valleys and the dense forests of the southern less to climatic differences than to the form in which the wealth of their respective inhabitants exists: in the one case, oxen, horses, sheep, and goats; in the other, well-tilled and neatly fenced fields and orchards. Though at first sight it appears difficult to believe that sheep and goats can destroy the forest over great stretches of country, a careful examination of the Upper Basil-su shows that the cause is sufficient to produce a continuous contraction of the forest area, and leaves it a mere question of time as to when the last tree in that valley shall be cut down and burnt. After overcoming many difficulties, Mr. Mummery reached the summit of Koshtantau, the first time the mountain had been scaled.

MR. HOLDER and his friends also succeeded in climbing Koshtantau and several other peaks. He gave in his paper an instructive account of the striking difference in the character of the mountains which form the two great chains of the Caucasus and the Alps. Mr. Holder was much impressed with the wildness, the majesty, the awfulness, of the Caucasus. Whilst the main glacier streams, *e.g.* the Bezingi, the Mishirgi, and the Dych-su, have but a slight fall, and are but little crevassed, the upper parts of the glaciers, those which come down from the mountains to form the great streams, have so steep a fall that they may be compared rather to cascades than streams of ice, and are cut into *seracs* of the most fantastic character. Comparatively little snow lies on the steep southern faces of the mountains, and the rocks which face the south are so broken and loose that the danger of falling stones in ascending and descending is extreme. No single bit of rock can be trusted, and the rope ought never for a moment to be discarded. On the northern faces much more snow lies, and the rocks were firmer and more reliable. The climate of the Caucasus is healthy and invigorating, yet distinctly more humid than in the Alps. It may perhaps be sufficiently interesting to note that none of the party experienced the slightest inconvenience on account of the rarity of the atmosphere at the highest altitude reached, over 17,000 feet; but that above about 15,000 feet the snow was always of the light and powdery character so tantalizing and fatiguing to mountaineers.

THE March number of *Petermann's Mitteilungen* contains a long paper by Spiridion Gopčević on the ethnographical conditions of Macedonia and Old Servia. Herr Otto F. Ehlers contributes a lively account of his ascent of Kilimanjaro last summer. He does not add much to our knowledge of the mountain, nor did he reach the actual summit. He went round its north face, and endeavoured from the north-east side to find out the character of the summit. He found the same wall of ice which was seen by Dr. Meyer. He states that so far as he could observe he could see no trace of a crater, while the masses of ice and snow lay in quiet wave-like lines, with much fresh snow. The height he estimates at over 19,690 feet. He makes the extraordinary statement that traces of elephants, buffaloes, and antelopes were met with at a height of about 16,000 feet, where also he found the last traces of vegetation.

M. JULES BORELLI has just returned from an exploration extending over nearly two years in the country of Shoa and in Galla Land, undertaken under the patronage of the French Government. M. Borelli has added much to our knowledge of Shoa and its people, and among other things has discovered the source of the Hawash. His most important work has, however, been done in the region to the south of Shoa, in the country peopled mainly by the Gallas. He traced the Omo River, to about 6° 20′ N. lat. His map throws quite a new light on the hydrography of the region. Hitherto, the Omo has been conjectured to be the upper course of the Jub, which falls into the Indian Ocean at the equator. But the data collected by M. Borelli, and which appear to be confirmed by the recent discoveries of Count Teleki, open the field to new hypotheses. It would appear that the Omo, instead of flowing towards the east, takes a westerly and then a southerly direction, when, at about 2° N. lat., with a breadth of over 1500 feet, it expands into the great lake Samburu. It remains now to discover whether this lake is an African Caspian, or whether it has an outflow towards Lake Victoria Nyanza. In that case the Omo becomes a remote feeder of the Nile.

ELECTRICAL NOTES.

NAGAOKA (*Phil. Mag.*, February 1889) of the Imperial University, Japan, has investigated the effects of torsion and longitudinal stress on the magnetization of nickel. Stress increases the magnetization of iron, but diminishes that of nickel, and the effect of torsion is also reversed in the two metals. Twisting nickel wire increases magnetization, while it diminishes that of iron. Nagaoka finds that this is true for weak stresses only. Beyond a critical value of the stress in a constant field, one end of the nickel wire acquires the two opposite kinds of magnetism during torsion and detorsion. The nickel wire used was unfortunately impure, for it contained 1·7 per cent. of iron, but the fact was clear that during untwisting the polarity of a nickel wire changed sign.

DR. JOHN HOPKINSON, F.R.S., has given the Royal Society (March 7) some interesting facts relating to the magnetization of iron at high temperatures. At 737° C. all traces of magnetism disappear, but before this point is reached, viz. 727°, its permeability increases with great rapidity to a very high figure, when it suddenly drops to unity. In a subsequent paper, read March 21, he showed that the resistance also makes an abrupt change at the same temperature, which is that of recalescence, as discovered by Barrett.

SHELFORD BIDWELL (R.S., March 14) showed a very pretty experiment by which the effect of radiations on the magnetization of iron were made evident. An iron bar is carefully annealed, cooled, magnetized, and then demagnetized by currents without any mechanical motion. The condensed beam from an oxyhydrogen lamp is thrown upon its pole, when magnetism at once appears. There is an instantaneous magnetic change, which is purely an effect of radiation.

A. BERNSTEIN (*Centralblatt für Electrotechnik*, i. p. 165, 1889) has proved that the formula $C = a\sqrt{d^3}$ is not true for the fusing currents of wires of a diameter smaller than 0·25 mm. It is known that such fine wires absorb more energy than thicker ones to acquire the same temperature in air, and that the formula is $C = ad$. Bernstein has experimented with carbons of different diameters in the moderate vacuum of a glow lamp, and has obtained the following results:—

Diameter in mm.	Energy per sq. mm. of surface.
0·9	0·51
0·56	0·54
0·295	0·56
0·185	0·85
0·15	0.95

His conclusion is that lamps with thick carbons absorb less energy relatively than lamps with fine filaments, and are therefore more economical.

C. S. BOWIE (*Electric World*, February 23, 1889) has found that the static electricity generated by calender rolls in a paper mill acts very injuriously on the life of glow lamps. They are now effectually protected with wire guards.

AMONG the numerous practical purposes to which electricity can be applied *tanning* must be added. Leather is said to be produced from the raw hide in four days.

IF Prof. Oliver Lodge has failed to secure general faith in his lightning conductor theories, he at least has succeeded in directing scientific fashion to experimenting with Leyden jars. Righi (*Bull. Acad. dei Lincei*, xii. 16, 1888) has constructed a battery of 108 condensers, having a capacity of 18,810 electrostatic units. With it he has produced sparks 5 metres long over strips of glass coated with zinc filings, and 1 metre long over water. Platinum, iron, brass, gold wires, very fine and of 3½ metres length, are instantly vaporized into beautiful coloured coronæ of the same shape as that impressed on the wire. The wire becomes vapour at a high temperature, and forms as it were a vacuum tube, the sides of which are cold air.

ON THE CONFLUENCES AND BIFURCATIONS OF CERTAIN THEORIES.[1]

AXIOMS, says Proclus,[2] are common to all sciences, though each employs them in its peculiar subject-matter. A little further on[3] he cites Aristotle[4] as saying that one science is more certain than another, viz. that which emanates from more simple suppositions than that which uses more various principles; and that which tells the why, than that which tells only the simple existence of a thing; and that which is conversant about intelligibles, than that which touches and is employed about sensibles.

Proclus adds that, according to these definitions of certainty, arithmetic is more certain than geometry, since its principles excel by their simplicity. For the conception of unity has no reference to position in space, while that of a point involves such reference. In short, we may say that to count a number of objects is a simpler operation than to measure the distances between them.

All this, and much more, shows how early the notion of what is sometimes called a hierarchy of the sciences arose. Proclus's order of precedence would seem to be this, viz. logic,[5] arithmetic, geometry, mechanics, optics, dioptrics,[6] and so on; the progression being from the more to the less abstract, or from the abstract to the concrete.

Francis Bacon, mindful perhaps of Proclus,[7] and duly appreciating the power of mathematics as an instrument[8] and its value as a discipline,[9] expressly takes the degree of abstractness of a science as the mark for its classification. He places mathematics, as the most abstract of sciences,[10] at one end of the scale and "policy" at the other. He does not graduate the scale minutely, but it may be that, as in the case of the categories,[11] he attached no great value to such details. Distinguishing philosophy from theology, logic, and mathematics,[12] he assigns to it the axioms which are common to several sciences and the inquiry into essences, as quantity, similitude, diversity, possibility, and the rest. Science he divides between metaphysics, the science of the abstract and permanent, and physics, that of matter and its changes.[13] Bacon, in one place, names the one universal science by the name of philosophy, while in another he treats philosophy and metaphysics as two distinct things.[14] He uses the word metaphysics in a sense different from that in which it was then[15] received. Mathematics he places as a branch of metaphysics, and as having determined or determinate quantity for its subject. To the pure mathematics, he says, belong geometry and arithmetic; the one handling continuous, and the other discrete quantity.[16] If he means continuous quantity so far as it is immovable, he agrees with the Pythagoreans.[17]

Quantity, time, and space are placed by Aristotle among his categories, or are implied in them. With regard to space, he does not seem to have reached the Kantian view in any way, nor to be very clear in his meaning, though he apparently feels that to realize space we must have motion. His conception of time as one of the elements required for measuring motion, and his starting the problem as to whether we could have time without a mind to conceive, seem a more distinct approximation, though only an approximation, to Kant's view of time as merely a subjective condition of perception.[18]

Newton, in the Scholium to his definitions, distinguishes between absolute and relative time, the latter being time conceived in its relation to phenomena. Of absolute time (otherwise called duration) which has no relation to anything external, he says that it flows equably, and that its rate of flow and the order of its parts are immutable. In his "Fluxions" he uses the word time in a somewhat different sense, viz. as meaning the independent variable, characterized by an equable increase, fluxion, or flow.[1] Sir W. Rowan Hamilton treated algebra as the science of pure time, but his doctrine is not entirely[2] assented to by De Morgan, nor by Prof. Cayley, who indeed, in his Southport Address (p. 19), intimates dissent from it. Proclus does not connect arithmetic with time, and Prof. Cayley suggests (*ib.* p. 18) that, in any case, the notion of number or plurality is not more dependent on time than on space. By the logicians, time seems to be regarded as the more abstract of the pure intuitions. In fact, time is implied in memory and in thought itself, and Prof. Francis W. Newman observes that no man could get through a syllogism if he forgot the first premiss while dwelling on the second.[3] Moreover, he has recourse to the idea of time when he comes to discuss propositions,[4] and Boole investigates the nature of the connection of his own secondary propositions with the idea of time.[5] The ancient Indians had their cyclical periods, but not therefore necessarily any notion of a uniform curvature (so to say) of time.

Absolute space, says Newton, perpetually remains similar to itself and immovable; and, further on in the Scholium, he adds that the order of its parts is immutable. In the preface to the "Principia" he had observed that the description of straight lines and circles, on which geometry is founded, belongs to mechanics, and he follows up this train of thought. But, whether he means to detach himself from Plato, I must leave others to say. It is said to be certain that he was familiar with Bacon's works; that he uses the word axiom, not in Euclid's sense, but in Bacon's, thus giving the name of axioms to the laws of motion, which, of course are ascertained by the scrutiny of nature, and to those general experimental truths which form the groundwork of optics.[6] Now Bacon says that, in his judgment, the senses are sufficient to certify and report truth, either immediately or by way of comparison.[7] Moreover, he suggests that the rule *Quæ in eodem tertio conveniunt, et inter se conveniunt*, a rule so potent in logic as that all syllogisms are built upon it, is taken from the mathematics.[8] In seeking an origin for the more abstract in the less abstract, Bacon is not solitary. Thomas Stephens Davies suggested[9] that the argument from superposition had its origin in mechanical considerations, and from the fitting together of material figures. Moreover, it is conceivable that some observant person among the ancient Egyptians, whose custom it was to stamp their bricks, noticing the resemblances of the marks and the correspondence of the impressions with the impressing tool, may have been led to a recognition of the rule quoted by Bacon. The doctrine that there enters into geometry an element derived from the senses has, indeed, appeared in books designed for ordinary readers. Thus, Prof. Newman, writing in 1836–38, although in one part

1 Presidential Address delivered by Sir James Cockle, F.R.S., to the London Mathematical Society, on November 8, 1888.

2 Proclus, "Commentaries on the First Book of Euclid's Elements" (Taylor's Translation, London, 1792), p. 92.

3 Proclus, *op. cit.*, p. 93.

4 Taylor (*ib.* p. 93) supplies the reference to the first Analytics, t. 42.

5 Proclus, *op. cit.*, p. 79. Hume ("Treatise," vol. i., London, 1739, Book i. Part 3, p. 129, *et vid.* p. 128) says that geometry falls short of that perfect precision and certainty which are peculiar to arithmetic and algebra.

6 Proclus, *op. cit.*, p. 93; *et vid.* pp. 78, 79.

7 Bacon, "The Proficience and Advancement of Learning" (Oxford, 1633), pp. 49, 50.

8 Bacon, *op. cit.*, pp. 151, 152; *et vid.* pp. 119, 120.

9 Bacon, *op. cit.*, pp. 152, 205, and 231.

10 Bacon, *op. cit.*, p. 218; *et vid.* pp. 150, 151.

11 Bacon, *op. cit.*, pp. 130, 131, 140, and 201; *et vid.* p. 161.

12 Bacon, *op. cit.*, pp. 49, 50; *et vid.* pp. 130, 131, and 140.

13 Bacon, *op. cit.*, p. 141.

14 Bacon, *op. cit.*, pp. 130, 140.

15 Bacon, *op. cit.*, p. 138; *conf.* pp. 146, 147.

16 Bacon, *op. cit.*, pp. 150, 151.

17 Proclus (Taylor's Translation), p. 74.

18 For this summary of Aristotle's views I am indebted to Mr. Reginald H. Roe, who referred me to Ueberweg's "Hist. of Phil.," p. 164, for a more general statement, and to p. 165 for a list of the best books for its fuller elucidation, adding that in Ritte and Preller's extracts, pp. 288 and 289, will be found all the important passages from Aristotle bearing on the question. As to the views of Boole, see his "Laws of Thought" (London, 1854), pp. 162 *et seq.*; see also p. 419. Boole treats of space at pp. 163, 175, and 418; and at p. 175 he quotes Aristotle's statements respecting the existence of space in three dimensions.

1 Newton, "Fluxions," pp. 26 and 38 of the small edition (London, 1737). This is a genuine work of Newton's. As to its bibliography, see *Notes and Queries*, 2nd S., vol. x. pp. 163, 232, 233; 3rd S., vol. xi. pp. 514, 515; 4th S., vol. ii. p. 316; 5th S., vol. iv. p. 401; 6th S., vol. iv. pp. 129, 130; vol. v. pp. 263, 264, 304, 305, and 426. This octavo edition is very scarce. Indeed, I only know of two copies, viz. my own copy and one in the library of the Royal Astronomical Society.

2 De Morgan, "On the Foundation of Algebra," Cambridge Transactions, vol. vii. pp. 173–87; see pp. 175, 176. The remarks of Prof. Cayley on Whewell, at p. 18 of his Southport Address, are applicable to Rowan Hamilton.

3 Newman, "Lectures on Logic, or on the Science of Evidence," &c. (Oxford, 1838), p. 15.

4 Newman, *op. cit.*, pp. 32–34.

5 Boole, "An Investigation of the Laws of Thought" (London, 1854), pp. 162 *et seq.*

6 See the account of the "Novum Organon" in the "Library of Useful Knowledge," p. 10.

7 Bacon, "Advancement of Learning" (cited *supra*), p. 193.

8 Bacon, *op. cit.*, p. 132.

9 T. S. Davies, Geometrical Notes, *Mechanics' Magazine*, vol. liii. (1850), pp. 150, 169, 262, 291, 442. Davies points out "the connection between parallels and similar triangles." He thinks that Aristotle's secession from the school of Plato arose from his enforcement of his own logical doctrines. Davies rejects the notion of a geometry built upon definitions alone without the assistance of axioms.

of his "Logic" (p. 25), he says that in geometry no results are admitted by help of observation and testimony, but only by reasoning from the definition, yet he afterwards (p. 55) states that, as space and its properties appear undeniably to be learned by sense, the argument seems to him to preponderate for naming geometry a mixed science, and believing that its propositions are real and not verbal truths. And Potts[1] says that geometry seems to rest on the simplest inductions from experience and observation, and that its principles are founded on facts cognizable by the senses.

But it is to Reid[2] that the idea of a more precise mathematical treatment of the subject is due, and his name ought to head the roll on which will be inscribed the names of Lobatschewsky, Riemann, and other investigators. Kant, indeed, disposes of such questions summarily, by saying that it follows from his premisses that the propositions of geometry are not the determinations of a mere creature of our feigning fancy, but that they necessarily hold of space, and consequently of all that may be met within it, because space is nothing else than the form of all the external phenomena, in which alone objects of sense can be given ("Prolegomena,"[3] p. 51). He adds (pp. 51 and 53) that external phenomena must necessarily and precisely agree with the propositions of the geometer. Whether Kant's allusion to "superficial metaphysicians" points to the Pyrrhonists and Epicureans[4] or to others, and, possibly, even to Reid, whom he had mentioned before (Preface, p. viii.), does not appear. Whatever opinions be formed of Kant's theory, or of the nature of space, his view is impressive. Confine that view to two dimensions, and suppose the surface of a sphere to be inhabited by a being destitute of any conception of a third dimension, and whose senses are unaffected by any point not situated or any motion not taking place on that surface. He could only estimate direction and position by the tangent to the path of the visual ray at the point where that path meets his visual organ, and would think that all objects were situate in one plane. His geometry would be Euclidian; for, if he could form a notion of the actual paths of rays, he would have a conception of the third dimension in space.[5] Here Kant and Riemann would apparently be at issue; for, if a more general conception of space is to be rendered special by actual measurements on the sphere, then, after an enlarged experience, the Euclidian conception would have to be expelled and replaced by some other. And all this would have to be done without praying in aid the excluded third dimension.

Aristotle[6] notices that the nature of everything is best seen in its smallest portions, and Kant[7] remarks that there was a time when mathematicians, who were philosophers too, began to doubt, not the truth of their geometrical propositions as far as they regard space, but the objective validity and applicability of the conception itself, and of all its determinations, to nature; as they were apprehensive that a line in nature might consist of physical points, and that consequently true space in the object might consist of simple parts, though space as conceived by the geometer cannot so consist. Clifford[8] would have given due weight to the doubts of the philosophical mathematicians. He even suggests that the properties of space may change with time. Now, a number may be a function of an angle; the very angle itself determines those numbers (ratios of lines) which we call sines and cosines. But, says De Morgan,[9] in every case but this it is impossible to conceive number a function of magnitude. It seems almost equally difficult to entertain Clifford's conjecture, which, nevertheless, measurements might verify. The sentence, *Nam tempora et spatia sunt sui ipsorum et rerum omnium quasi Loca*, in Newton's Scholium, though it may suggest that omnipresence does not involve extension in space, implies no functional relation between space and time. The words "then and there," accompanying every material allegation in indictments, would suffice to show that the opinions of the world at large on certain characteristics of time and space[1] were in accord with that of the philosophers. Indeed, their isolation, as forms of intuition, may no more be a peculiarity of Kant's system than is his distinction between analytical and synthetical judgments. This distinction was present to the mind of Bacon,[2] as well as to that of Locke, whom Kant cites ("Prolegomena," p. 25), and who, elsewhere than in the place cited, adverts to the distinction. That which Locke had styled a trifling proposition, Kant called an analytical judgment; and that which Locke ("Essay concerning Human Understanding," book iv., chap. viii., Sect. 8) styled a real truth, Kant would would have called a synthetical judgment. With Hume, too, Kant is in some respects in close relation. Hume ("Treatise," vol. i., book i., part 2, pp. 53-124) treats specially of the ideas of space and time. Hume, again ("Inquiry," p. 17; Essay iv., p. 50), distinguishes between results attained by reasonings *a priori* and results arising entirely from experience ("Inquiry," p. 17; Essay, p. 49). He seems to allow conception a sufficiently wide range, for he urges ("Inquiry," p. 13; Essay ii., pp. 26, 27) that, in one exceptional instance, there may be an idea not arising from a corresponding impression; viz. in the case when from the impressions of two distinct shades of a particular colour, a conception is formed of an intermediate shade of the same colour. He asserts ("Inquiry," p. 118) that the only objects of the abstract sciences or of demonstration are quantity and number.

If, as Clifford[3] seems to think, there are no sufficient grounds for maintaining that, if our space has curvature, it must be contained in a space of more dimensions and no curvature, one difficulty is apparently removed. The one-dimensioned time is something very different to space, from which the higher-dimensioned entity might differ still more; and if a solid be treated as the shadow or projection in Euclid's space of, say, a four-dimensioned body, that part of the body which lies outside the shadow seems to have no quality analogous to impenetrability or inertia, nor indeed any quality which affects the senses or deranges the results of calculation. Prof. Cayley says (Southport Address, p. 11) that Riemann's idea seems to be that of modifying the notion of distance, not that of treating it as a locus in four-dimensional space. The suggestion (Cayley, *ib.* p. 10) of a rule changing its length by an alteration of temperature facilitates apprehension. Prof. von Helmholtz has considered the effect of the changes in sensible phenomena which a transition to a spherical or pseudo-spherical world, if such things be, would produce; and he has taken an independent view of the subject in other respects.[4]

De Morgan[5] professed to have been puzzled to know on which side the meeting of parallels took place, or whether on both. He concludes that they never meet. This, however, does not shake, nor is it to be supposed that he wished[6] it to shake, the belief in modern methods, for he apparently admits that interpretation of forms may demand conclusions which can be reached by reasoning on infinity, if increase without limit show approach. He observes that it is clearly conceived by the logicians that all division is reducible to simple dichotomy and its repetitions, and that when the logician has once shown division, difference, he does not trouble himself with the difficulty of repetitions. De

[1] Potts (Robert), "Euclid's Elements of Geometry," &c. (Cambridge and London, 1845); Notes to Book i., p. 41.

[2] Thomas Reid. "An Inquiry into the Human Mind on the Principles of Common Sense" (1764). My pagings refer to the Calcutta Reprint of 1869. Chapter vi. treats (pp. 94-277) of Seeing; its Section vii. (pp. 120-24), of Visible Figure and Extension; and its Section ix. (pp. 132-45), of the Geometry of Visibles. In Section viii. (pp. 125-32), we have Some Queries concerning Visible Figure answered.

[3] I cite from Richardson's Translation (London, 1819); and cannot now give the corresponding paging in that of Prof. Mahaffy.

[4] Montucla, "Histoire" (2de édition, An. vii.), p. 21.

[5] See Cayley, Southport Address, pp. 11, 12.

[6] See Bacon, "Advancement of Learning," p. 108.

[7] Kant, "Prolegomena," p. 52.

[8] William Kingdon Clifford, "Mathematical Papers" (London, 1882). See pp. xl. and xli. of the Introduction, by H. J. S. Smith.

[9] De Morgan, "On the General Principles of which the Composition or Aggregation of Forces is a Consequence" (Camb. Trans., vol. x., part 2, pp. 294, 295, footnote).

[1] I should have been glad to have given Locke's and Kant's descriptions of space and time, and to have compared them with Newton's. But I cannot omit to refer to a Smith's Prize paper, by Mr. Robert Franklin Muirhead, printed in the *Philosophical Magazine* for June 1887, S. 5, vol. xxiii. pp. 473-89.

[2] Bacon, "Advancement of Learning," p. 47.

[3] Clifford, "The Universal Statements of Arithmetic" *Nineteenth Century* (1879, vol. v., pp. 513-22; *vide* p. 522).

[4] A paper in *Mind*, by Prof. von Helmholtz, elicited a criticism from Prof. Land, which produced a reply; and with a brief note appended to a paper on another subject, by Prof. Land, the discussion closed. See *Mind*, vol. i. pp. 301-21; vol. ii. pp. 38-46; vol. iii. pp. 212-25 and 551-55; and vol. iv. pp. 591-96.

[5] De Morgan, "On Infinity," &c. (Camb. Trans., vol. xi. Part 1, 1865, pp. 145-89; *vid.* pp. 173, 176, 180, 147). In connection with this paper, the comments of Mr. W. S. B. Woolhouse in the *Educational Times* (Reprint, vol. vi. pp. 49-52) should be considered. And in connection with a paragraph at pp. 161, 162, of De Morgan's paper, the leading paragraph of p. 424 of a previous paper of his, "On the Theory of Errors of Observation" (C. T., vol. x. Pt. 2, 1862), should be read. In the last-mentioned passage he distinguishes between the zero and the indivisible of probability. Hamilton, of Edinburgh, following earlier authorities, expressly restricts the application of logic to finite things. But it does not therefore follow that logicians in general turn a deaf ear to all reasoning upon infinities and infinitesimals, and that they reject results stamped with authority and universally accepted.

[6] This sufficiently appears from a statement at p. 15 of his paper, "On the Root," &c. (Camb. Trans., vol. xi. Pt. 2).

Morgan's remark is easily verified by turning to Potts's Note on Euc. i. 10 (p. 49). Turning again to Boole ("L. of T.," p. 91), it would seem that the logician does not completely detach himself from the notion of infinity: he has to interpret 1 : 0 as well as 0 : 0.[1]

Bacon differs from Plato, who considered forms as absolutely abstracted from matter, and not as confined and determined by it, and agrees with Aristotle in saying that words are the images of thoughts;[2] so that the agreement of the views of Bacon with those of Prof. Max Müller would seem to be tolerably close. It is easy to find cases in which a doubtful meaning of a word may give rise to disagreement on matters of substance. Boole ("L. of T.," pp. 407, 408) observes that the term "necessary" may be applied either to the observed constancy of nature or to the logical connection of propositions. He expresses no decided preference for either meaning. The meanings should be kept carefully apart. If an axiom be a necessary truth, in the strictest sense, then Newton's laws of motion are laws *a priori*, viz. giving Kant's meaning to the term ("Prol.," p. 103); they are known independently of all experience. But Laplace ("Méc. Cél.," pp. 14–18[3]) treats them as results of experience. Moreover, he treats (pp. 65–69) the laws of motion under all the relations mathematically possible between force and velocity. Newton, in fact, usually speaks of "law," and gives the term "axiom" Bacon's meaning.

Boole's chapter xx. ("L. of T.," pp. 320–75) relates to problems on causes, but his use of the word "cause" has given rise to much discussion. He proposed a question on causes in 1851, which was answered by Prof. Cayley in 1853. The solution was criticized by Boole in 1854, who arrived at a different result, and in 1854, Mr. H. Wilbraham examined both solutions. Prof. Cayley returned to the subject in 1862, and Boole thereupon admitted that it would have been better, in stating his problem, not to have employed the word "cause" at all.[4] One mode of stating the nature of the relation between "cause" and "effect" may be this, viz. when a certain (antecedent) change is immediately and invariably followed by a certain other (subsequent) change, then the relation in which the antecedent stands to the subsequent (which may now be called the consequent) change is that of cause and effect. This is, in substance, if not in form, a view common to Algazel, Glanvil,[5] Hume,[6] Brown,[7] Kant, and, as I believe, Reid; for the question seems to be one about words. It differs but slightly from the view (C. T., vol. x., part 2, p. 300) of De Morgan. Perhaps "unvarying" might be a better word than "invariable," for one instant of time is the immediate and invariable antecedent of its consecutive instant; but the idea of "cause" does not seem to arise. When "cause" is used in the above sense, the solutions of Boole and Prof. Cayley agree. Boole's question has been dealt with in our Proceedings (vol. xi. p. 118) by Mr. McColl.

The import of the word "principle" is not the same when we speak of the principle of contradiction or of excluded middle, as when we speak of the principle of the permanence of equivalent forms, or of the sufficient reason, or of continuity. That of sufficient reason has been assailed by Brown ("C. and E.," sect. iv. pp. 222, misnumbered 322, to 306), and by De Morgan (C. T., x., part 2, pp. 290–304). Clifford (*op. cit.*, p. xl.) was prepared to sacrifice the principle of continuity, even in the case of space, and the author of anonymous "Strictures" on Peacock's "Algebra" (Camb., 1837), who was (so at least I was told many years ago by Davies) Hind, concludes (p. 21) that number is perfectly abstract, that it is the only thing which is so, that it is not rightly denominated a species of quantity, being equally connected with every species. An instance of a striking failure of the principle of the permanence of equivalent forms is given by Dr. J. W. L. Glaisher in the *Messenger of Mathematics*, N. S., vol. ii. (1872) p. 95. Again, take another word —viz. "disparity." Supposing it to be said that there are two persons in a room, whose united ages are twenty-one years, and between whose ages there is the greatest disparity possible. This is intelligible if one be a new-born or nascent infant, and the other a person aged twenty-one. But suppose the same statement made of three persons; the proficient in language might have to inquire of the mathematician what meaning, if any, the statement bears. Or, again, the mathematician might be asked what, or whether any, numerically definite meaning can be attached to the words, "triangle of maximum scalenity."

Prof. Newman ("Logic," 1838, p. 52) says that the truths of arithmetic are verbal. Perhaps this, and the corresponding statements of Dugald Stewart, would not now be insisted on. They are opposed to the views of Kant, Clifford, and De Morgan (C. T., xi., part 1, p. 160). The identities $3^2 + 4^2 = 5^2$, and $3^3 + 4^3 + 5^3 = 6^3$, seem to be something very different from definitions of words. Kant considers $7 + 5 = 12$ to be a synthetical judgment ("Proleg.," pp. 22, 23).

Metaphysics and mathematics are consorts in the East as well as in the West. Bhascara says that the analytical art is merely sagacity exercised, and is independent of symbols, which do not constitute the art.[1] If De Morgan[2] be right in placing Diophantus as late as the beginning of the seventh century, Aryabhatta was earlier, by two centuries, than Diophantus. The name certainly seems to have been a very common one. Josephus[3] relates that Alexander (a son of Herod the Great) said that Diophantus the scribe had imitated his hand. But Mr. Heath's work[4] renders it scarcely possible to sustain De Morgan's contention.

[1] See the last footnote but one.

[2] Bacon, "Advancement of Learning," p. 143; *conf.* pp. 130, 140. See also pp. 192, 209.

[3] My pagings refer to the 2nd ed. of the "Mécanique Céleste," vol. i. (Paris, 1829).

[4] Boole, *C. and D. M. J.*, vol. vi. p. 286; "L. of T.," pp 321–26; *Phil. Mag.*, S. 4, vol. vii. pp. 29–32; vol. xxiii., pp. 361–63; Wilbraham, *Phil. Mag.*, S. 4. vol. vii. pp. 465–76; Cayley, *Phil. Mag.*, S. 4, vol. vi. p. 259; S. 4, vol. xxiii. pp. 352–65, and 470. A short letter by Boole (*Phil. Mag.*, S. 4, vol xxiv. (1862), p. 80, concludes the discussion.

[5] Glanvil (Joseph), "Scepsis Scientifica," &c. (Lond., 1665, 4to); Lond., 1885, 8vo. On Causation, I have only mentioned comparatively recent authors. But, going further back, we find Thales (with his elemental analysis), Xenophanes (with his one cosmic substance), and Pythagoras (with his arithmetical and geometrical combinations), all recognizing invariable sequences in nature; and Socrates admitted a class of phenomena wherein the connection of antecedent and consequent was invariable and ascertainable by human study (Grote, "History of Greece," vol. i., 1846, pp. 495–98). Socrates applied similar scientific reasonings to moral and social phenomena (*ib.*, p. 504).

[6] David Hume, "A Treatise of Human Nature," &c. (Lond., vols. i. and ii., 1739; vol. iii., 1740: his name does not appear on the title-pages). "Philosophical Essays concerning Human Understanding" (2nd ed., Lond., 1750). "An Inquiry concerning Human Understanding" (Lond., 1861) marks the issue to which I refer.

[7] Thomas Brown, "Inquiry into the Relation of Cause and Effect" (3rd ed., Edinburgh, 1818). Draper does not admit the construction put upon Algazel's words by Whewell ("Hist. Ind. Sc.," Lond., 1837, i. p. 251). A facsimile reprint of Glanvil has been published within the last few years. Buckle pronounced Brown's to be one of the best books ever written.

[1] Colebroke, "Algebra," &c. (London, 1817), p. xix.

[2] De Morgan, "Arithmetical Books" (London, 1847), p. 47.

[3] Josephus, "Antiquities of the Jews" (Burder's Translation, vol. i. pp. 616, 617). Burder's preface is dated London, October 1, 1811.

[4] T. L. Heath, "Diophantos of Alexandria: a Study in the History of Greek Algebra" (Cambridge University Press, 1885).

EXHIBITION OF METEOROLOGICAL INSTRUMENTS.

THE Royal Meteorological Society's tenth annual Exhibition of Instruments was held in the rooms of the Institution of Civil Engineers, 25 Great George Street, Westminster, from the 19th to the 22nd instant. This Society's Exhibitions are always interesting and instructive, as each one is devoted to some special class of instruments: this year the instruments consisted principally of actinometers and solar radiation apparatus. Specimens of most of the various forms of these instruments were exhibited; but when it was not possible to obtain an instrument itself, a photograph or drawing of it was shown, so that the visitors to the Exhibition could readily see what instruments have actually been made.

Several specimens were exhibited of Sir John Herschel's actinometer, for ascertaining the absolute heating effect of the solar rays, in which time is considered one of the elements of observation. This consists of a large cylindrical thermometer bulb, with a special open scale, so that minute changes may be easily seen. The bulb is of transparent glass filled with a deep blue liquid, which is expanded when the rays of the sun fall on the bulb. When taking an observation, the actinometer is shaded for one minute and read off; it is then exposed for one minute to sunshine, and its indication recorded; it is finally shaded again, and its reading again noted. The mean of the two readings in the shade, subtracted from that in the sun, indicates the expansion of the liquid produced by the sun's rays in one minute of time.

The Kew Committee exhibited Hodgkinson's actinometer, the principle of which is the same as that of Sir J. Herschel's, and also Pouillet's direct pyrheliometer, which consists of a cylindrical box of steel filled with mercury, into which the bulb of a thermometer is introduced, the stem being protected by a piece of brass tubing. As the surface on which the sun's rays fall and the quantity of mercury in the cylinder are both known, the effect of the sun's heat upon a given area can be expressed by stating that it is competent in five minutes to raise so much mercury so many degrees in temperature. The Rev. F. W. Stow showed an improved form of Pouillet's pyrheliometer, in which the instrument is placed in a silvered tube to shield it from wind and from all solar rays, except when the tube is turned directly towards the sun. Mr. Casella exhibited Secchi's solar intensity apparatus, in which two thermometers are kept immersed in a liquid at any convenient temperature, and a third, of which the stem passes through the same liquid and the bulb is outside it, is exposed to the rays of the sun shining down the hollow cylinder. The increase of temperature thus obtained is found to be the same, independent of the temperature of the liquid which surrounds the thermometer.

The British Association Solar Radiation Committee showed Prof. Balfour Stewart's actinometer; and Dr. Ångström, of Stockholm, sent one of his pyrheliometers and a photograph of another pattern.

Luvini's dietheroscope for observing the changes of atmospheric refraction optically, and Bellani's lucimeter, as arranged by Prof. G. Cantoni for use at the Italian meteorological stations, were exhibited by the Meteorological Council; and Mr. Hicks showed some of Crookes's radiometers.

Dr. A. Downes illustrated his method of slow actinometry by oxalic acid, in which a definite quantity of a standard solution of oxalic acid is exposed to the action of light for a definite period; subsequently it is used to bleach a standard solution of permanganate of potash. The quantity of oxidized oxalic acid solution, compared with the quantity originally required to produce the same effect, is a measure of the intensity of the light.

Engravings illustrating Violle's, Crova's, and Frölich's actinometers were also exhibited.

The solar radiation thermometer consists of an ordinary maximum thermometer, with the bulb and about one inch of the stem coated with lamp-black, inclosed in a glass shield exhausted of air. Various specimens of this instrument were exhibited, with arrangements for testing the degree of exhaustion. Hicks's black bulb maximum thermometer *in vacuo* is supplied with platinum wires and a battery for testing the vacuum, while Negretti and Zambra's has a mercurial test gauge. Mr. Hicks also showed one of these instruments which had at the end of the outer jacket a second chamber in which is mounted one of Crookes's radiometers for testing the vacuum.

The Royal Meteorological Society showed a pair of black-bulb and bright-bulb maximum thermometers *in vacuo* as recommended for use at the Society's stations; while Messrs. Negretti and Zambra exhibited a similar pair of thermometers mounted in an upright position with the bulbs uppermost, as used at the Montsouris Observatory, Paris.

Mr. Casella showed Southall's helio-pyrometer for testing the accumulated heat of the sun in a confined blackened space, under glass. A black-bulb maximum thermometer is fixed on a cushion at the bottom of a box, the sides of which are also cushioned, and a thick piece of plate-glass is laid upon the top to prevent currents of air carrying off the heat. The box is placed in such a position that the sun's rays may strike as nearly as possible perpendicularly on the glass, when water contained in a small vessel will boil violently in the box.

The practical working of sunshine recorders may be said to date from 1854, when Mr. J. F. Campbell mounted a hollow glass sphere filled with acidulated water in the centre of a bowl of mahogany so arranged that the sun's rays were focussed on the interior of the bowl and burned it. The lines of burning therefore indicated the existence of sunshine. Solid glass spheres were substituted for the hollow ones in 1857, and in 1875 cards in metal frames were substituted for the wood. The Meteorological Council exhibited a number of wooden bowls showing the effect of sunshine by burning in the years 1855–56, 1883–84, and 1887–88; and the Astronomer-Royal sent the sunshine recorder with a hemispherical metal bowl which was in use at the Royal Observatory, Greenwich, from 1876–86. Specimens of the Campbell sunshine recorder with the improved Stokes's zodiacal frame for a fixed latitude, were shown by the Meteorological Council; a recorder with adjustments for use in any latitude, by Messrs. Negretti and Zambra; and the Whipple-Casella sunshine recorder, by Mr. Casella.

Mr. Jordan exhibited an experimental instrument for recording the intensity of daylight, the results being obtained by revolving a disk of sensitized paper behind a screen with a rectangular aperture. Messrs. Negretti and Zambra showed the various patterns of Jordan's photographic sunshine recorder, which consists of a cylindrical box, on the inside of which is placed a slip of cyanotype paper. Sunlight being admitted into this chamber by three small apertures, is received on the paper, and travelling over it by reason of the earth's rotation, leaves a distinct trace of chemical action. In the second pattern of this instrument two apertures are used instead of three; while in the new pattern two semi-cylindrical boxes are employed, one to contain the morning and the other the afternoon record. Prof. McLeod's photographic sunshine recorder was exhibited by Mr. Hicks. This consists of a glass sphere silvered inside and placed before the lens of a camera, the axis of the instrument being placed parallel to the polar axis of the earth. The light from the sun is reflected from the sphere, and some of it passing through the lens forms an image on a piece of sensitized paper within the camera.

Mr. A. S. Marriott showed two patterns of his instrument for comparing the active value of light at different stations; and the Kew Committee sent the chemical photometer devised by Sir Henry Roscoe.

Among the new instruments exhibited were Fineman's and Galton's nephoscopes for observing the direction of motion of clouds; Davis's improved air meters; Negretti and Zambra's recording hygrometer; Casella's Boylean-Mariotte barometer; and de Normanville's self-compensating sympiesometer. Mr. Murday showed in action his apparatus for obtaining readings of an aneroid placed at a distance by means of electric currents. An instrument, called the stephanome, which is used at the Ben Nevis Observatory for measuring the angular size of halos, fog-bows, glories, &c., was also exhibited.

Mr. Clayden showed a very ingenious and instructive working model illustrating the generation of ocean currents, which was a great attraction to all the visitors at the Exhibition. This model shows how the prevalent winds over the Atlantic are the chief cause of the circulation of the waters. A number of tubes are so arranged that when an attached blower is worked the circulation of air produced resembles that of the atmosphere; the imitation winds thus set up react upon the surface of the water, creating a system of currents which reproduces the main features observed in the Atlantic. Special attention was drawn to the Gulf Stream issuing from the Gulf of Mexico, and to the return current flowing eastwards between the equatorial currents. Mr. Clayden also showed some lantern slides illustrating the spiral circulation of the wind in both a cyclone and an anticyclone.

One of the chief features of last year's Exhibition was the large collection of photographs of flashes of lightning which had been gathered together by the Royal Meteorological Society from all parts of the world; this year the Society exhibited a number of similar photographs which have been received since May 1888. Near to these were placed a number of photographs of the electric spark taken by Mr. Wimshurst when the sensitive plate was rotating 2500 times per minute. These flashes are quite sharp and distinct, and show no sign of the movement of the plate.

A very interesting and valuable collection of sixteen photographs taken on the summit of Ben Nevis during the last eleven months were exhibited by the Directors of the Observatory, of which the following were of special interest: (1) cirrus cloud at the northern horizon, taken at midnight at the time of the summer solstice when the clouds are seen brightly illuminated; (2) St. Elmo's fire, at 11 p.m., on the top of the stove-pipe; and (3) views of the Observatory after continued fog and strong wind, but no fall of snow, when everything is covered with long crystals of ice formed out of the fog.

Mr. Bromhead exhibited two large photographs showing the thick rime on trees at Lincoln on January 7 last; and Mr. H. P. Curtis showed a photograph taken by moonlight.

Photographs of clouds were exhibited by Captain Wilson-Barker, Mr. Shepherd, and Captain Maclear.

The Exhibition also included a number of photographs and drawings of instruments, &c., as well as some models of hailstones, 7 inches in circumference, which fell near Montereau, France, on August 15, 1888.

WILLIAM MARRIOTT.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The recent discussion on the proposed new buildings for anatomy and physiology disclosed that the Financial Board do not consider that the whole plan can be proceeded with at present. They hold that only £10,000 is available; but this is because it is proposed to diminish the annual contributions from the Colleges for some years. It appeared to be agreed that the lecture-room or middle block could be best dispensed with if absolutely necessary, the blocks of physiological and anatomical class-rooms and dissecting-rooms being most essential. Prof. Foster mentioned that the labour of conducting the practical classes in physiology was so great as to leave no time for research, and to strain the health of himself and his demonstratoıs almost to the point of breaking down. The present buildings not only limited but spoiled their work.

The adjudicators of the Hopkins Prize in connection with the Philosophical Society have recommended that it be awarded to Sir William Thomson for his mathematical researches upon the theory of the tides, and other important investigations in mathematical physics.

The General Board of Studies has issued a report deprecating the proposed diminution of College contributions, and showing that that proposal will destroy any chance of appointing new teachers, or increasing the small stipends now paid to University lecturers and readers, or of making any payments in aid of research. A great number of detailed needs for all the departments are specified, the scientific Boards being well represented. The Reader in Botany and the Lecturer in Animal Morphology and others are strongly recommended for immediate increase, and a capital expenditure of £30,000 is needed for museums, laboratories, lecture-rooms, &c.

The following is the subject for the Adams Prize to be adjudged in 1891:—The motion of a satellite about a spheroidal planet, and the reaction on the planet. The ordinary approximation is supposed to be inadequate, either because the ellipticity of the planet is too great, and the distance of the satellite too small, or because the obliquity of the orbit is too great. It is also desired that the influence of a distant disturbing body (such as the sun) may be taken into account in so far as is found practicable. The successful candidate will receive about £170, but is required to print the essay at his own expense.

The report on the local examinations of last December states that in chemistry the answers were on the whole satisfactory, but chemical calculations were in general inaccurately performed. In heat, the juniors answered badly, the senior boys better, but many of the senior girls were quite ignorant of the subject. In statics, dynamics, and hydrostatics, the juniors had not grasped the elementary ideas, while the seniors did better, except in the arithmetic of calculations. The answers seem to show that these physical subjects are not suitable for juniors. In electricity and magnetism, taken only by seniors, the boys did well. The botanical answers varied greatly at different centres, and questions on flowering plants were much better answered than those on cryptogams. In zoology the elements were known, but many answers were very wordy and irrelevant. Several seniors described the structure of a Vorticella rather well, but also named and described the mouth-appendages of a crayfish (the specimen being before them) likewise as a Vorticella.

SCIENTIFIC SERIALS.

American Journal of Science, March.—Some determinations of the energy of the light from incandescent lamps, by Ernest Merritt. Two series of experiments are described, which have been carried out for the purpose of determining what portion of the energy supplied to a lamp is given off as light, and what proportion is wasted practically as dark heat. In the first, based on Melloni's calorimetric method, the light is separated from the dark heat by passing the radiations to be measured through a thin layer of water, or, better still, through a solution of alum in water. The energy of the dark heat, which is almost entirely absorbed, is then measured by the rise in temperature of the water, and that of the light by a thermopile. In the second process the calorimeter was abandoned, and a cell, 1 decimetre thick, containing a strong solution of alum, was used for absorbing the dark heat. The light, after passing through this cell, was allowed to fall on a thermopile, and the deflection was observed. Then the alum cell was removed, and the deflection corresponding to total radiation was observed, the ratio of the two deflections giving the ratio of the light energy to the total energy. This being determined by electrical measurements, the energy of the light could be calculated.—On the ophiolite of Thurman, Warren County, New York, with remarks on the *Eozoon canadense*, by George P. Merrill. This ophiolite, a kind of verdantique marble, is found to be an alteration, or metasomatic product after a mineral of the pyroxene group. Its constitution promises to throw some light on the Eozoon problem.—On the origin of the deep troughs of the oceanic depression; are any of volcanic origin?, by James D. Dana. A general survey of the oceanic regions leads to the inference that volcanic action can only have had a very subordinate part in determining the origin and position of the great marine depressions. Their source must be sought still less in superficial causes, such as erosion, but rather in the interior agencies of primordial development. The paper is accompanied by a bathymetric map of the Pacific and Atlantic, based on the recent charts of the British and United States Hydrographic Departments.—Description of a problematical organism from the Devonian, at the Falls of the Ohio, by F. H. Knowlton. These puzzling organisms, here provisionally named *Calcisphæra lemoni*, from the collector, have been submitted to various American and European palæontologists, and the evidence both for and against the view that they are a fruit of Chara, is given in detail.—Papers are contributed by George H. Williams, on the geology of the Island of Fernando de Noronha (part 2, petrography); by S. L. Penfield, on some curiously developed pyrite crystals from French Creek, Delaware County, Pennsylvania, and on some crystallized bertrandites from Maine and Colorado; and by J. S. Diller and J. E. Whitfield, on dumortierite from New York and Arizona, peridotite from Kentucky, and gehlenite occurring in furnace slag in Pennsylvania.

THE *Memoirs of the Novorossian* (Odessa) *Society of Naturalists*, vol. xiii. fasc. 1, contain a series of papers on the late L. Cienkowski, by P. Boutchinsky, W. Zalensky, L. Richavi, G. Sadkowsky, and S. Karwatzky, being full reviews of the late Professor's extensive scientific work, and giving a full bibliography of his contributions to science.—The next papers of importance are: on the rainfalls in South-Western Russia, by A. Klossovsky; on the copulation of the nuclei of cells during the sexual processes of Fungi, and on the absorption of water by the overground parts of plants, by W. Chmielevsky; on the Jurassic beds of Orenburg and Samara, by I. Sintsoff, being revised lists of fossils found in various parts of these provinces; on the action of methylene-iodide upon the ether of malonic acid, by S. Tanatar; and on the influence of the medium, and especially of temperature, upon *Planorbis vertia*, by Mary Balashova.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 7.—"On the Cranial Nerves of Elasmobranch Fishes. Preliminary Communication." By J. C. Ewart, M.D., Regius Professor of Natural History, University of Edinburgh. Communicated by Prof. Burdon Sanderson, F.R.S.

This paper contains a short account of the cranial nerves of *Læmargus microcephalus* and of *Raia batis*, and it is especially shown that in connection with the roots of the trigeminal and facial nerves there are altogether five large ganglia—one of them apparently representing two ganglia—and that in connection with the vagus there are three separate ganglia in Læmargus and six in Raia. It is further pointed out that the nerve to the lateral line arises by a special root quite distinct from the rest of the vagus complex, and that it is provided with a separate ganglion, and also that the mucous canals of the head and trunk, together with the numerous ampullæ of the sensory tubes, are either supplied by nerves belonging to what is termed the facial complex or the lateralis division of the vagus complex.

Attention is especially directed in Læmargus to the following facts: (1) that the ganglion of the ophthalmicus profundus lies only very slightly in front of the ganglion (Gasserian) of the trigeminal; (2) that there is no connection between the oculo-motor nerve and the ophthalmicus profundus ganglion; (3) that the ciliary nerves spring from the trunk of the ophthalmicus profundus some distance in front of its ganglion; (4) that neither in any part of the trunk or main branches of the oculo-motor nerve nor in connection with the branches which pass from the oculo-motor to join the ciliary branches of the ophthalmicus profundus are there any ganglionic cells; (5) that the so-called facial consists of four separate nerves, the ophthalmicus superficialis, buccal, palatine, and hyomandibular—the last receiving a special bundle of fibres while still in the cranial cavity from the ophthalmicus superficialis; (6) that there are numerous ganglionic cells at the base of the palatine nerve—the nerve which is said to correspond to the great petrosal nerve of higher Vertebrates; and (7) that the lateralis nerve supplies the aural mucous canal as well as the canal of the lateral line.

In Raia the following points are brought out, viz., (1) that the ganglion of the ophthalmicus profundus, which is some distance in front of the Gasserian ganglion, lies over the deep branch of the oculo-motor nerve, from which minute branches pass *under* the ophthalmicus profundus ganglion to join two or more of the ciliary branches of the profundus; (2) that the ciliary branches usually arise from the under surface or outer edge of the ganglion of the ophthalmicus profundus, none of them except on rare occasions springing as in Læmargus from the trunk in front of the ganglion; (3) that were the root and trunk of the ophthalmicus profundus greatly reduced in size an arrangement similar to that which exists in the higher Vertebrates would be produced, and the ganglion of the ophthalmicus profundus would appear to especially belong, as has often been taken for granted, to the oculo-motor nerve; (4) that the nerve, generally stated to correspond to the chorda tympani of higher Vertebrates, consists chiefly of fibres which spring from the large ganglion at the base of the hyomandibular nerve; (5) that the ganglion of the lateralis lies several inches (three or four) from the origin of the nerve, and that in addition to supplying the canal of the lateral line the lateralis supplies the dorsal pleural mucous canal, the aural canal, and part of the occipital; (6) that the five additional ganglia of the vagus complex are disposed as follows, one for each of the four branchial nerves, and one for the intestinal nerve.

In this preliminary communication the segmental value of the various cranial nerves is not considered, but it is pointed out that further investigations may show that the ganglia in connection with the superficial ophthalmic buccal palatine and hyomandibular nerves are related to the geniculate, otic, sphenopalatine, and sub-maxillary ganglia of the higher Vertebrata.

Physical Society, March 9.—Prof. Reinold, President, in the chair.—Prof. O. J. Lodge read a paper on magneto-optic rotation by transient currents, with reference to the time required for the production of the effect. If a piece of heavy glass, or tube of carbon bisulphide, be placed between two crossed Nicols, and surrounded by a solenoid, light passes through when a Leyden jar is discharged through the wire. That the discharge is oscillatory, may be proved by turning the analyzer slightly to one side or the other, this having no effect on the result; or the beam may be examined by a revolving mirror, in which case a beaded band is seen when the discharge takes place. When the spark itself is analyzed in the same way, a serrated band results. The frequency of the oscillations being given by the formula—

$$n = \frac{1}{2\pi\sqrt{\frac{LS}{\mu K}}},$$

it is evident that n will be decreased by increasing the capacity S and self-induction L, and this fact was demonstrated by connecting two condensers, first in series and then in parallel, and placing coils of wire in the circuit. The pitch of the sound emitted by the spark was by these means brought within the musical scale. Contrary to expectation, the insertion of a coil with an iron core produced little or no change in the pitch, the reason given being that the induced currents in the skin of the iron wire due to such rapid oscillations of current prevent the interior being magnetized. From the mathematical theory of the brightening of the dark field, it appears that the relative brightness, B, when compared with the light field obtained from the uncrossed Nicols, is given by—

$$B = \frac{1}{\tau}\int_0^\tau \sin^2\theta dt,$$

where τ is the time during which an impression can be accumulated on the retina, and θ the angle through which the polarized beam is rotated. When θ is considered small,

$$B = 16\pi^2 k^2 n^2 \frac{\frac{1}{2}SV_0^2}{R\tau},$$

where k = Verdet's constant, n = number of convolutions on the solenoid, R = resistance of circuit, and $\frac{1}{2}SV_0^2$ = the initial energy of the static charge. The general solution is given as—

$$B = \frac{1}{2m\tau}\int_0^A \frac{1 - J_0(x)}{x} dx,$$

where $m = \frac{R}{2L}$, $A = 8\pi kn\mu V_0 \sqrt{\frac{S}{L}}$, and $J_0(x)$ Bessel function.

Taking the approximate solution, the question as to what is the best size of wire wherewith to wind the solenoid is considered, and as the insulation is very important, it is concluded that the secondary of a Ruhmkorff coil is very suitable. The main interest of the experiment is said to lie in the evidence afforded of the practical instantaneity of the development of the rotary property in the substance under examination, for Villari (from experiments made on a glass drum revolving in a magnetic field) inferred that a distinct time, between 1/800 and 1/400 of a second, was necessary, whereas Profs. Bichat and Blondlot, of Nancy, have concluded that the time required is less than 1/30000 of a second. The author finds that carbon bisulphide is able to show the effect when the rate of alternation is 70,000 per second, and has no reason to believe that glass is in any way inferior. As a possible explanation of Villari's results, he suggests that the strain due to centrifugal force would modify the components of the polarized beam, and produce elliptic polarization. Mr. Ward mentioned that experiments similar to Villari's were now being carried out at the Cavendish Laboratory, a disk of glass being rotated about two hundred times per second by means of a turbine. The results so far obtained do not confirm Villari's, but, owing to difficulties in keeping the speed constant, it is difficult to make exact measurements. It has, however, been found that the strain due to centrifugal force rotates the plane of polarization, and elliptically polarizes the beam; and that passing an alternate current round a stationary glass bar produces a distinct rotation of polarized light passing through it. Referring to the oscillatory discharge of a jar, Prof. Rücker directed attention to Dr. E. Cook's experiments, described before the Society in June 1888, when photographs showing the dust-figures produced by sparks were exhibited, and pointed out that the frequency required to produce air-waves of the length there indicated was of the same order as the rate of oscillatory discharge—viz. about one million per second. Prof. Rücker also wished to know whether glass behaved precisely like CS_2. Dr. Lodge said his experiments were not exact enough to decide the latter question, and mentioned that Mr. Chattock had, some time ago, produced dust-figures in tubes by jar-discharges, and shown that the wave-length depended on the capacity and self-induction. Prof. Ayrton suggested the use of a phonograph as a means of recording and reproducing the oscillations, in the same way as himself and Prof. Perry have analyzed the current-curves of alternating dynamos. The discharge could be passed through a small coil fixed to a diaphragm, and placed near a coil through which a steady current was passing, the attractions and repulsions serrating the surface of the rapidly revolving cylinder. By means of a mirror attached to a delicate magnifying spring, the section of the surface may be determined. He also inquired whether the experiments shown do prove that the effect is instantaneous. Dr. Thompson remarked that it was satisfactory to learn that Villari's results admit of an interpretation other than by time effect, and thought it advisable to vary the experiment by rotating a bar of glass; but Mr. Ward said he attempted that experiment four years ago, and abandoned it on account of the enormous speed required.—Dr. Lodge showed some experiments allied to those of Hertz, and pointed out that all the effects were due to resonance. The plates of an air-condenser were connected by a wire loop, and placed near a Holtz machine in action. On adjusting the distance between the plates to a particular value, sparks were observed to pass between them; but, on increasing or decreasing that distance, the sparks ceased. It was also shown that the sparking was interrupted if the connecting loop was replaced by a coil, though the coil was effective when connected to a condenser of smaller size, thus demonstrating that the time-constant of the condenser circuit was all-important. Another important condition to be observed in such experiments is, that the receiving circuit must be closed, except at the sparking place, so as to permit the surgings of the electricity to take place freely. Other experiments were shown, in which two spheres provided with rods terminating in knobs were used as a Hertz's oscillator, and sparks could be obtained from straight pieces of wire of suitable length held at some distance from the spheres. Dr. Lodge remarked that sparks could be obtained from almost any scrap of wire or metal in close proximity to an induction-coil and oscillator; but, to produce the effects at considerable distances, careful timing of the receiving circuit was necessary. The author also mentioned the results of some experiments on the velocity with which electric waves travel along wires, and concluded (contrary to Hertz) that this was not greatly different from the velocity of light.—Owing to the late hour, the other papers announced to be read were postponed.

Entomological Society, March 6.—The Right Hon. Lord Walsingham, F.R.S., President, in the chair.—Mr. F. P. Pascoe exhibited several specimens of the Saüba Ant (*Œcodoma cephalotes*) from Parà, carrying portions of dried leaves. It seemed questionable whether the leaves were collected by the ants for the purpose of making their nests, or for the sake of some Fungus which might be growing on them.—Mr. Jenner-Weir exhibited, and read notes on, specimens of a Butterfly (*Tirumala petiverana*) from Mombaza, Eastern Africa.—Mr. J. H. Durrant exhibited a living larva of *Cossus ligniperda*, which had entirely lost its ordinary colour, and had become first pink and then white. He attributed the change, and subsequent loss, of colour to the fact that it had been deprived of its natural food, and fed for eighteen months on pink paper, with which the box in which it was kept was lined, and subsequently on white cardboard. Mr. McLachlan remarked that the most extraordinary peculiarity about this larva, in addition to the loss of colour, was the absence of the usual odour of *Cossus*. Lord Walsingham observed that it was questionable whether the colours of larvæ were dependent on the colours of their surroundings, or whether they were affected by the contents of the intestinal canal. Prof. Meldola, F.R.S., said that the caterpillar exhibited, having eaten the pink paper, had most probably become dyed by the colouring matter, and he did not think the observation had much bearing on the question of the protective colouring of caterpillars. It was well known to physiologists that certain dye-stuffs could be introduced into the tissues of animals by mixing the colouring-matters with the food, and paper was frequently stained with coal-tar dyes, such as eosin, magenta, &c., so that it was simply a case of direct dyeing of the larva.—Mr. B. A. Bower exhibited a specimen of *Parasia neuropterella*, bred from heads of *Centaurea scabiosa*, and said he believed the species had not been previously bred. He also exhibited series of *Coleophora olivaceella, C. solitariella*, and *Laverna subbistrigella*.—Mr. White exhibited a series of male and female specimens of *Orgyia thyalina*, obtained by the late Mr. H. J. Pryer in Japan. Some of the females had their wings fully developed, and some of them were semi-apterous, as is usual with the females of this genus. Mr. White remarked that he knew of no other species of the genus in which the females had fully-developed wings. Lord Walsingham, Prof. Meldola, and Mr. R. South took part in the discussion which ensued.—Lord Walsingham exhibited specimens of preserved larvæ of *Eupithecia extensaria*, from King's Lynn; also a preserved larva of *Smerinthus ocellatus* and one of *Sphinx ligustri*. The larva of the last-named species was a variety, and the President remarked that it was the only one of this species he had ever seen.—The Secretary read a communication from the Rev. Dr. Walker, announcing his intention of making an expedition to Iceland this year, from June 23 to July 29, and asking that any entomologists who might wish to accompany him would send him their names.—Mr. Distant suggested that the meeting should pass a resolution expressing regret at the death of the Rev. J. G. Wood.—Mr. Gervase F. Mathew, R.N., communicated a paper entitled "Descriptions and Life-histories of New Species of Rhopalocera from the Western Pacific."

Zoological Society, March 5.—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 February 1889, and called attention to four Marbled Polecats (*Putorius sarmaticus*), presented by Colonel Sir Oliver B. C. St. John, new to the collection; and to a fine specimen of Owen's Apteryx (*Apteryx oweni*) from the South Island of New Zealand, presented by Prof. T. Jeffrey Parker.—Mr. A. Thomson exhibited a series of insects reared in the Insect House in the Society's Gardens during the past year, and read a report on the subject.—Prof. G. B. Howes exhibited and made remarks on some specimens of the embryo of *Myrmecobius fasciatus*.—Mr. O. Thomas exhibited a specimen of a new Muntjac from Tenasserim, lately discovered by M. Fea, and proposed to be called *Cervulus feæ*.—A communication was read from Mr. Joseph S. Baly, containing descriptions of some new South American Coleoptera of the genus *Diabrotica*.—A communication was read from the Rev. H. S. Gorham, containing descriptions of some new species and a new genus of the Coleopterous family Telephoridæ, from Eastern Asia. Thirty-nine new species and one new genus (for which the name *Lycocerus* was proposed) were described. Of these new forms, the greater part were from India and China.—Colonel R. H. Beddome read a paper on new land-shells from the Island of Koror (Pelew Group), based on specimens collected for Dr. Hungerford by a resident in that island. The series comprised examples of eight new species of the genus *Diplommatina*, of two new and very curious species of *Endodonta* (a section of *Helix*), and of a remarkable new genus, allied to *Diplommatina*, proposed to be called *Hungerfordia*.—Mr. W. E. Hoyle read a paper on the anatomy of a rare Cephalopod (*Gonatus fabricii*), originally discovered by Fabricius in the last century, but little known in recent times. The author gave a general description of the anatomy of the species, and recorded the existence of several tracts of cartilage hitherto unobserved in the Cephalopoda. Some details were given regarding the structure of the pen-sac and the development of the pen, as well as some new facts reregarding the structure of the funnel-organ, and a suggestion regarding its function. The genus was regarded as being somewhat more nearly related to *Onychoteuthis* than to *Enoploteuthis*, but as much further removed from them both than they are from each other. The creation of the sub-family Gonatidæ was thus held to be justified.

Mathematical Society, March 14.—Mr. J. J. Walker, F.R.S., President, in the chair.—The following papers were read:—Notes on plane curves: iv., involution-condition of a cubic and its hessian; v., figure of a certain cubic and its hessian, by the President (Mr. E. B. Elliott in the chair).—The problem of duration of play, by Major MacMahon, R.A.—Some results in the elementary theory of numbers, by Mr. C. Leudesdorf.—The characteristics of an asymmetric optical instrument, by Dr. J. Larmor.—A new angular and trigonometircal notation, with applications, by Mr. H. MacColl.

EDINBURGH.

Royal Society, March 4.—Sir W. Thomson, President, in the chair.—A paper, by Dr. J. Oliver, on deductive evidence of a uterine nerve-centre and of its location in the medulla oblongata, was communicated.—The President exhibited a gyrostatic model of a medium capable of transmitting waves of transverse vibration. The model was two-dimensional, but a three-dimensional model could readily be constructed on the same principle.—Dr. Thomas Muir read a paper on the relation between the mutual distances of five points in space. He has reduced Cayley's determinant to one of the fourth order.—Dr. Muir also communicated a note, by Prof. Tait, on the relation among four vectors. In this note Prof. Tait gave an investigation of the same problem by means of quaternions. His result can be interpreted in two ways; one interpretation leads to Dr. Muir's result, while the other gives the well-known relation among the sides and diagonals of a spherical quadrilateral.—Dr. Muir exhibited a diagram illustrating the history of determinants.—Dr. Noel Paton and Dr. Ralph Stockman communicated a paper on the metabolism of man during starvation.

March 18.—Dr. John Murray, Vice-President, in the chair.—Prof. Haycraft read a contribution, written by Dr. Harold Scofield and himself, to the chromatology of the bile.—A paper by Prof. Tait on a relation between two groups of four vectors was read. When the two groups are identical, the result reduces to that obtained by him in his paper read at last meeting. When one spherical quadrilateral is the polar of the other, the relation reduces to $\cos Ab \cos Bc \cos Cd \cos Da = \cos Ac \cos Bd \cos Ca \cos Db$. Cayley's determinant can at once be obtained from the identity $\Sigma x(\alpha - \theta)^2 = \Sigma x\alpha^2 - 2S\theta\Sigma(x\alpha) + \theta^2\Sigma(x)$, where there are five vectors $\alpha_1 \ldots \alpha_5$, and $\Sigma(x) = 0$, $\Sigma(x\alpha) = 0$, by replacing θ by the various vectors α in turn and eliminating the x's from the resulting equations by aid of the equation $\Sigma(x) = 0$.—A paper by Mr. John Aitken, describing a portable apparatus for counting the dust particles in the atmosphere, was read. This apparatus is constructed on the same principle as his former one, but various improvements have been made. The paper also included an account of some of Mr. Aitken's observations with the large apparatus. It is pointed out that when much dust is present in the atmosphere the heat of the sun is greatly absorbed. Hence it seems probable that dust particles may aid in the formation of fogs in another way than by acting as nuclei. Their great radiating power will cause rapid cooling of the air, and so produce saturation.—Dr. Sims Woodhead communicated a paper, by Mr. R. W. Gray and himself, on the stomach of the narwhal. —Dr. Crum-Brown read the third part of a paper, by Dr. A. B. Griffiths, on micro-organisms.—A second note by Prof. Tait, on the virial equation, was read.

PARIS.

Academy of Sciences, March 18.—M. Des Cloizeaux, President, in the chair.—On the fixation of nitrogen during the process of slow oxidation, by M. Berthelot. The object of these researches is to determine the fixation of nitrogen during the slow oxidation especially of those principles that give rise to certain intermediate oxides endowed with mixed oxidizing and oxidizable properties which temporarily fix free oxygen, afterwards transforming it to an almost indefinite extent to other bodies capable of definite oxidation. Such are ordinary ether, the essence of terebenthine, various aromatic hydrocarbons, and other substances capable of producing those effects which their discoverer, Schoenbein, attributed to ozone.—On the heat of formation of antimoniuretted hydrogen, by MM. Berthelot and P. Petit. The formation of this extremely unstable compound is described, and its heat of formation determined by six experiments at − 84·5 calories.—On the essays that have been made to explain the fundamental principles of thermodynamics by mechanical laws, by M. H. Poincaré. The paper deals mainly with the views developed by Helmholtz in his memoirs on the statics of the monocyclic systems, and on the principle of least resistance (*Crelle's Journal*, vols. xcvii. and c.). M. Poincaré accepts the mechanical explanation as satisfactory for the reversible phenomena, but shows that it is not applicable to those of the irreversible order.—On certain fourfold periodical expressions depending on two variables, by M. E. Picard. In this note the author indicates certain series depending on two independent complex variables, and possessing in relation to them four couples of conjugated periods.—On the movement of a material point on a sphere, by M. Gustave Kobb. In his treatise on some applications of the elliptical functions, M. Hermite has reduced the integration of the equations in the movement of the conic pendulum to the integration of Lamé's differential equation. Here M. Kobb shows that there also exists another kind of movement of a material point on a sphere which leads to a similar application of Lamé's equation.—On the elastic equilibrium of arches forming arcs of circles, by M. Ribière. Two typical cases are worked out mathematically, which offer a complete solution of the problem of the elastic equilibrium of circular vaults.—On the solubility of salts, by M. H. Le Chatelier. The author replies to some critiques on his own researches (*Comptes rendus*, vol. c. p. 50), made by M. Bakhuis Roozeboom, in the remarkable work recently published by him on the solubility of salts.—On the chloride and bromide of copper, by M. Denigès. The author describes a simple process for preparing these substances by means of the haloid salts of the alkalies and the sulphate of copper. The same chemist indicates a new and characteristic reaction of the salts of copper, the principle of which rests on the easy transformation of these salts into cupric bromide under the influence of potassium bromide, and on the dehydratation of the resulting salt by means of sulphuric acid. —Researches on the saccharine substances contained in certain species of mushroom, by M. Em. Bourquelot. These researches have been made on eight species belonging to the genus *Lactarius* of Fries, and to Sowerby's *Boletus aurantiacus*. The proportion of mannite was found to vary from 1·90 to 15 per cent., according to the different species, and sometimes in the same species from season to season. From *Lactarius piperatus* a substance was obtained identical with M. Berthelot's trehalose, the presence of which in mushrooms had already been indicated by M. Müntz.—On the physiological and therapeutic action of orthomethylacetanilide, by MM. Dujardin-Beaumetz and G. Bardet. This substance, which has recently been prepared by M. Brigonnet under the name of exalgine, with formula $C_9H_{11}NO$, is toxic, therapeutic, and anæsthetic, according to the dose administered. In these respects it greatly resembles antipyrine, but appears to be superior as a cure for all forms of neuralgia.—Thermic classification of fresh-water lakes, by M. F. A. Forel. Lacustrine basins are here grouped as tropical, temperate, and polar, according as the surface waters are always above, about, or under 4° C. respectively. But with this grouping is combined the variation of temperature due to depth, this variation increasing with the shallowness of the lake. Further modifications are caused by special climatic conditions, such as altitude, latitude, aspect, volume, so that from the thermic stand-point every fresh-water basin has its special features. All are comprised in six broad classes, based, however, mainly on the two more important elements of surface temperature and depth.

BERLIN.

Physical Society, February 22.—Prof. von Helmholtz, President, in the chair.—Prof. Neesen demonstrated several pieces of mechanical apparatus which he is in the habit of using in his lectures to illustrate and explain the parallelogram of forces, the laws of inertia, and the action of friction with special reference to the slipping of locomotives. He further described several arrangements connected with mercurial air-pumps by which some of their defects and inconveniences may be avoided. —Dr. Wolff gave an account of the results of a long series of measurements which he had made on galvanic cells, consisting of zinc and zinc sulphate or chloride and a second metal, either copper, silver, or iron. By determining the electromotive force of each cell and the simultaneous heat-production (by means of an ether calorimeter), he endeavoured to prove that the source of the current-energy in each case is due to the combining of oxygen with the several metals, copper, silver, or iron. He hence considered himself justified in giving the name "oxygen-elements" to the above class of galvanic cells.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Chemical Lecture Notes: P. T. Austen (Wiley, New York).—The Scientific Transactions of the Royal Dublin Society, vol. iv. (series 2), ii. A Monograph of the Marine and Fresh-water Ostracoda of the North Atlantic and of North-Western Europe; Section I., Podocopa: G. A. Brady and Rev. A. M. Norman; iii. Observations of the Planet Jupiter: O. Boeddicker; iv. A New Determination of the Latitude of Dunsink Observatory: A. A. Rambaut (Williams and Norgate).—The Patents, Designs, and Trade Marks Acts, 1883–88, consolidated, with an Index: L. Edmunds (Stevens). —Longmans' New Atlas: edited by G. G. Chisholm (Longmans).—British Dogs, Nos. 27, 28, 29: H. Dalziel (U. Gill).—Travel-Tide: W. St. Clair Baddeley (Low).—Naturalistic Photography: P. H. Emerson (Low).—Stellar Evolution and its Relations to Geological Time: J. Croll (Stanford). —Naturalist's Voyage round the World: C. Darwin (Murray, 3s. 6d.).—Northern Afghanistan: Major C. E. Yate (Blackwood).—Modern Cremation: Sir Henry Thompson (K. Paul).—Cosmic Evolution: E. A. Ridsdale (Lewis). —Physical Geography and the Climate of New England: W. M. Davis (Camb., Mass.).—Proceedings of the Academy of Natural Sciences of Philadelphia, October–December 1888 (Philadelphia).

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