THURSDAY, FEBRUARY 13, 1902.

THE CAMBRIDGE SCHOOL, AND A ZOOLOGICAL TEXT-BOOK.

Zoology, an Elementary Text-Book. By A. E. Shipley, M.A., of Cambridge, and E. W. McBride, M.A. (Camb.). D.Sc. (Lond.), of Montreal. Pp. 616 ; 349 text-figures. (Cambridge: University Press, 1901). Price 10*s*. 6*d*. net.

YET another elementary text-book of zoology! The accumulation of facts in zoology during the last quarter of a century has been so overwhelming, that it becomes most difficult even to gauge the capacity of a book like the present, which deals broadly with the whole field. Choice of subject-matter is so wide, selection so difficult, that, in the endeavour to form an estimate of such a work, the mere determination on the part of the reviewer of a standard of comparison upon which to judge it, is in itself an arduous task. Let it be said, however, that the senior author of the present volume has an established reputation as a text-book writer, and that his previous achievements have led us to expect a sometimes thinnish mode of treatment. While in this we are not disappointed, under the joint authorship a very creditable book has been produced.

There are twenty-three chapters in all, the first of which is an "introduction" dealing with broad principles and first definitions. The contents and style of this are such as might be expected from a well-trained first-year man, and are apt to create a false impression of the rest of the book. This simplicity of treatment, however, is intentional, and expressive of the authors' scheme—for they tell us they have aimed at producing a book which can "be readily understood by a student who had no previous knowledge of the subject," and that the phraseology of the later portions of the work is relative to the earlier. Technical terms are explained as they occur, with roots in original Greek, and with fuller definitions where necessary. "Biogen" is introduced as denoting the living molecule. Histology, embryology and palæontology are intentionally placed at a discount, the treatment of classification, and of adult structure "as the outcome of function and habit," being the guiding principle. The several sections of the work treat each of selected individuals of a phylum, and the position and interrelationships of these in the general scheme of classification are for each section concisely stated, with a short diagnosis, in an accompanying table—an arrangement favourable to lucidity in the text, of which the authors have made the most.

Following the introduction are chapters on the Protozoa, Cœlenterata and Porifera. The Cœlomata are ushered in with an introduction special to themselves, and the leading Invertebrate phyla—viz. the Annelida, Arthropoda, Mollusca, Echinodermata, and Chætognatha—are in order dealt with. Seven chapters are next devoted to the Vertebrata; and there are reserved for the four which conclude the volume the Platyhelminthes, Nemertinea, Rotifera and Nematoda, regarded as phyla which cannot be definitely asserted to be Cœlomata. A decidedly novel arrangement this! but, under it, the Entoprocta (barely mentioned on p. 286) appear to have escaped adequate recognition, which is the more remarkable since the Chætognatha are accorded some three or four pages.

As a whole, the book is well written and up to date, and of the illustrations, those which are new are mostly good, those borrowed well chosen. Diagrams are given, especially where dealing with the circulatory system, and some of those of the venous channels might well be improved. There pervades the pages of the work a freshness of style and unconventionality which render them pleasant reading and attractive; while, in the frequent allusion to the commonest occurrences of daily life and human affairs, the interest of the reader is assured. The chapters on the Porifera and Annelida may be cited as thin and inadequate, there being no mention of the horny sponges, of the genus Oscarella, or of the branchiate Oligochætes. Correspondingly slender is the treatment of the "Anacanthini" and Insectivora, the paragraphs upon which are miserably poor. Of definitions, that of the Cyclostomata may be instanced as erroneous, in the non-recognition of the Bdellostomoid forms possessed of more than seven pairs of gill pouches, and the statements concerning the "bile-duct" and the branchial basket-work (by comparison with p. 347), Dohrn having shown the "extra-branchials" to be extended gill-rays.

The description of the pancreas as a mere "outgrowth from the intestine" is insufficient, by non-recognition of its compound origin, now demonstrated for all gnathostomatous groups; and, similarly, it is nowhere stated that the pulmonary artery is now known to be in all its forms a derivative of the fourth branchial arch. Nor is there mention of the highly significant transitional conditions of the heart (conus and its valves) occurring among the Clupesoces. Again, a most important point is lost in the ignoring of the circular type of the so-called semicircular canals, and the invariably saccular innervation of that which is posterior. And, finally, to pass to minor misstatements, we would remark that the forwardly directed process of the chelonian shoulder-girdle is a scapular derivative (proscapula) occurring only in these creatures and the Plesiosauria; that the epipterygoid (columella) is not confined to the Lacertilia; that the pre-hallux of the Batrachia is not definitely proved to be a digit homologous with the rest; and that the bone which suspends the ophidian mandible is most certainly the supra-temporal.

We are also of opinion that too full an assurance is attached to the supposed quadripartite nature of the "arco-centrum." This, as a vertebral theory, was elaborated at Cambridge; and we similarly find the Balanoglossoid, also favoured of the Cambridge school, set forth with all its best traditions—but why not Cephalodiscus and Rhabdopleura as well? They are not even mentioned.

One of the most noteworthy features of this book is the tardy recognition of the facts of comparative embryology and palæontology, and it is the more remarkable that the subordination of the former in a work written by two Cambridge men, should have been decided upon, at a time when embryological discovery of far-reaching significance is being made known. In this book the treatment of even larval forms is but casual and passing, and were the discovery (now fifty years old) of the test-bearing protrochal stage of Dentalium, lately observed by Drew to be passed through by Yoldia and by Pruvot by a Dondersia, but recognised, we should not find the Chitons referred to a subclass of the Gastropoda and the "Solenogastres" accorded a class distinction. To this developmental stage, the discovery of which has dealt the death-blow to the idea of a Rhipidoglossan affinity of the Pelecypoda, and which, we trow, will ere long be extended to other groups, our authors should have directed attention. Had they done so, but three lines would not have sufficed for the Scaphopoda, and Spirula would not have been dismissed as a mere name.

Turning to palæontology, the non-recognition of the recent discovery in the Trilobites of nauplius characters deprives the authors' treatment of this larva of all force. And, similarly, had the Eurypterid forms recently described by Holm from the Russian Silurian, by Beecher from the Cambrian, and the Scorpionid genus Palæophonus, met with recognition, Limulus could not in justice have been once more relegated to the Arachnida. The absence in the present book of all mention of the Odontorinthes and Archæopteryx, of the Anomodontia, the Plesiosauria, and other leading fossil forms which might be named, is a serious omission, but even this does not excuse the non-reference to so important a group as the living Sphargidæ. Embryology and palæontology are branches of morphology coequal with the rest, and, so far as they reveal facts of primary significance, they should be dealt with as elementary subjects. Lack of appreciation of this principle is the weakest feature of the present work, which is, curiously enough, written with a special view to the requirements of the American student, who, of all beginners, is brought up in a palæontological air, and for whose benefit examples, wherever possible, are drawn from American as well as British animals.

Allowing for this serious defect, the book can be confidently recommended as well written and trustworthy, so far as it goes. It has been compiled at great pains, and its style leaves little to be desired. We wish it success and a speedy passage into a second edition; and, in anticipation of this, we would recommend to the authors' consideration the need of revision of such definitions as that of the endoderm cell (p. 48) as "tall"; of the blood-vessels (p. 89) as "chinks"; the replacement of the term "rudiment" on p. 259 by blastema; and certain other loosenesses which are self-evident. It is pertinent to this to remark that in some of their recent attempts at revised terminology, the zoologists of the Cambridge school have been none too successful. Thus, we note in the account of the life-history of the New Zealand reptile Sphenodon, given in the recently published natural history volume on "Amphibia and Reptiles," that the writer has substituted the word "æstivation" for what its discoverer rightly termed a hibernation. Is it possible that he has temporarily confused the southern summer with our own?

Of the illustrations, it may be said that figs. 266, 289 and 299 are examples which are poor, and might well be replaced; the statement that of the 32,000 "known species of Vertebrata" some 10,000 are Teleostei is surely excessive.

MATHEMATICAL TEXT-BOOKS IN THE UNITED STATES.

College Algebra. By J. H. Boyd, Ph.D. Pp. xxii+788. (Chicago: Scott, Foresman and Co., 1901.)

WE cannot obtain a complete view of the state of mathematical studies in a country merely by examining the text-books and treatises which are in vogue there; but we do, in this way, gain a good deal of information about the aims and standards of its mathematical teachers. Dr. Boyd's treatise illustrates very well the qualities and defects of American methods, and suggests a few general remarks, as well as particular criticisms, which may not be out of place.

First of all, it must be acknowledged that the excellences of the better class of mathematical authors in the United States greatly outweigh their deficiencies. The American student is alert and inquisitive; he is neither impervious to new ideas, nor unwilling to make experiments. Moreover, teachers and students alike regard mathematics in the proper spirit—as a science which has, indeed, a venerable history, but is at the same time living and progressive, with ever new developments and ever fresh applications to the needs of man. Many, if not most, of the leading mathematicians in the States have studied in Germany, and have thus become acquainted with the work of Kronecker and Weierstrass and the far-reaching influence of this upon function-theory and the foundations of analysis. In elementary geometry, too, they are not the slaves of tradition, as we are; and it is not impossible that they may ultimately give us the ideal class-book in geometry for which we are waiting.

Dr. Boyd, in his preface, accepts the modern standard of rigour, and in his choice of topics combines the indispensable rudiments with those developments and applications which are really important. The general scope of his book may be indicated by saying that Book I. deals with the fundamental laws of operation; II. with equations of the first degree; III. with indices, surds and complex quantities; IV. with quadratic equations; V. with proportion, progressions and logarithms; VI. with induction, permutations and combinations, and the binomial expansion for a positive integral exponent; VII. with limits and series; VIII. with the properties of determinants and the elementary theory of equations.

After proving the fundamental laws of operation for the cases where they are arithmetically intelligible, the author extends them by purely formal definitions; thus $(a-b)$ is defined by the formal equivalence $(a-b)+b=a$. This is unobjectionable, but seems to us to require more justification than Dr. Boyd explicitly gives. He appeals to the "principle of permanence of form," but this "principle" remains practically an assumption. No doubt it would be extremely tedious to give (what we think has never been done) a complete logical proof that the application of the generalised laws of operation never involves an inconsistency; still, something more might have been done to help the reader to apprehend the reasonableness of the assumption.

Again, Dr. Boyd is not always consistent with himself. Thus, in the chapter on fractions, he begins with the formal definition $\frac{a}{b}\times b=a$; he subsequently says that

4/7 means that a group of 7 things is regarded as a unit group out of which 4 things are taken; and finally gives a proof of the equivalence of 4/7 and 12/21 by means of a graduated scale. This is mixing up three different ways of looking at the matter in a fashion which is very likely to cause confusion. And, so far as his "group" definition goes, he gives it in an imperfect form which is not immediately applicable to improper fractions and which fails to account for the equivalence of a pair such as 4/7 and 12/21.

Another chapter to which we naturally turn is that on irrational numbers and limits. Irrational numbers are treated, after Cantor, as the limits of sequences; and the discussion is satisfactory so far as it goes, though it might well be made rather more complete and is occasionally rather illogical. Thus, for instance, in the early part of the chapter it is said that the ordinary rule for finding a square root, when applied to 2, leads to the inequalities

$$1 < \sqrt{2} < 2, \quad 1{\cdot}4 < \sqrt{2} < 1{\cdot}5, \quad 1{\cdot}41 < \sqrt{2} < 1{\cdot}42,$$

and so on. As thus stated, the proposition is a pure *petitio principii*. The sequence $(1, 1{\cdot}4, 1{\cdot}41, \ldots)$ is convergent, and may be rationally combined with other such sequences according to Cantor's rules; therefore it may be regarded as a number. By definition

$$(1, 1{\cdot}4, 1{\cdot}41, \ldots)^2 = (1^2, 1{\cdot}4^2, 1{\cdot}41^2, \ldots),$$

and this sequence can be proved to be equivalent to 2; therefore $\sqrt{2}$ is an appropriate symbol for $(1, 1{\cdot}4, 1{\cdot}41, \ldots)$. We must not begin by assuming the existence of $\sqrt{2}$ as an arithmetical quantity. The proof that sequences obey the laws of operation is put very briefly, and when we turn to the chapter on surds, we find that such an equivalence as $\sqrt{2} \cdot \sqrt{3} = \sqrt{6}$ is justified, not by the use of sequences, but by a reference to the purely formal law of indices. Here, again, we have a rather unfortunate association of two entirely different notions. If, for any purpose, we like to introduce a symbol θ such that $\theta^2 = 2$, every rational function of θ can be reduced, by formal processes, to the shape $P + Q\theta$, where P and Q are independent of θ; this is quite independent of the question whether θ can be properly regarded as a number or not; still less does it assign to θ its place in the arithmetical continuum.

Dr. Boyd's chapter on the binomial theorem for any exponent deserves attention, because, although it requires supplementing, it is novel, at least in a text-book, and may prove to be a good way of explaining the theorem to the college student. Let p/q be a positive rational fraction; then

$$(1+x)^{p/q} = \sqrt[q]{(1 + px + \tfrac{1}{2}p(p-1)x^2 + \ldots + x^p)}.$$

Now it can be shown, as Dr. Boyd indicates without going into detail, that we can, by a process which is, in fact, Horner's method, determine a polynomial

$$y = 1 + \frac{p}{q}x + c_2x^2 + c_3x^3 + \ldots + c_mx^m,$$

such that

$$(1+x)^p - y^q = R = Ax^{m+1} + Bx^{m+2} + \ldots + Lx^{qm},$$

where m is any positive integer assigned beforehand. The coefficients c_2, c_3, &c., are numerical, and it can be proved by the method of undetermined coefficients that

$$c_2 = \tfrac{1}{2}p(p-q)/q^2, \ldots c_r = \left(\frac{p}{q} - r + 1\right)c_{r-1}/r,$$

for $1 < r < m+1$. By making m an indefinitely large integer, y becomes an infinite series, which is convergent for $|x| < 1$. It remains to be proved that the sum of the infinite series y, when convergent, represents that branch of the function $(1+x)^{p/q}$ which reduces to 1 when x is zero. This last part of the proof Dr. Boyd has failed to supply or even to indicate; the need of it will be seen when it is observed that when y becomes an infinite series, the remainder R is also an infinite series, and it is essential to prove that, as m increases indefinitely, the limit of R is zero.

It will not be amiss to observe that these criticisms, offered with all friendliness and sympathy, are provoked just *because* Dr. Boyd aims at a high standard of logical exactitude. Many a worse book than his may be said to have fewer faults—faults, that is, which lie on the surface and can be pointed out in a few words. To write a really sound book on algebra, not incomprehensible to the ordinary college student, and not hopelessly unscientific when judged from the standpoint of contemporary analysis, is a very difficult task. But it is a worthy one; and the attempt justifies itself, even if it is not crowned with unqualified success. The reader of Dr. Boyd's book cannot fail to gain many fruitful ideas; if he has mathematical capacity he will very likely apprehend them in a substantially correct form, even when the author's exposition is not entirely rigorous.

To sum up, we find in this treatise, as in others of its class, much that is fresh, vital and stimulating; an interest in the progress of research, and in the development of new conceptions; together with a style that is neither frivolous nor pedantic. What we miss is, on the one hand, the German thoroughness which spares no pains to make the logical chain of an argument complete, and, on the other, our English dexterity of manipulation. This last faculty is not of much importance, truly, but is worth reasonable cultivation. It is strange to us, for instance, to find a whole page spent on the decomposition of $x^4 + px^2 + q$ into a product $(x^2+\alpha)(x^2+\beta)$ without any reference to the fact that $x^4 + px^2 + q$ is a quadratic in x^2. It is only fair to say that, in this instance, the context partly accounts for the phenomenon; but other examples of needlessly complicated work could easily be given. G. B. M.

A CANADIAN PIONEER IN SCIENCE AND EDUCATION.

Fifty Years of Work in Canada, Scientific and Educational. By Sir William Dawson, C.M.G., LL.D., F.R.S. Pp. viii + 308. (London and Edinburgh: Ballantyne, 1901.)

LITTLE more than a year has passed since the friends of science and of education in Canada had to mourn the death of Sir William Dawson. Though for the last six years of his life he had retired from his active official duties, his pen was not allowed to remain idle, but continued to throw off papers for scientific journals, addresses to societies and books of a more or less popular kind. One of the occupations of these closing years appears to have been the preparation of a sketch of his own career, which he left complete even to the dated preface with instructions to his son to have it published as early as might be practicable after his death. Dr. Rankine Dawson has accordingly fulfilled the charge committed to him, and the result is a little volume entitled "Fifty years of Work in Canada, Scientific and Educational."

To those who were privileged with Sir William's friendship or acquaintance, the autobiography will recall many of the traits of his character, many little touches of manner and expression, and many of the moods of thought which showed themselves in his familiar talk. But to those who knew him not, the book will hardly reveal what manner of man he really was. Its readers will learn from it, indeed, that he must have been an enthusiastic student of nature, an upright and earnest and indefatigable teacher, an evidently kindly and genial man who with infinite patience and perseverance, and obviously with consummate tact and skill, fought and won the battle of higher education, for women as well as for men, in a colony where everything had to be begun from the beginning, and where the hindrances and opposition might have daunted a braver pioneer. It traces his life in outline from his boyhood at Pictou in Nova Scotia to his final retirement in the cottage at Little Métis, where, after a slight paralytic seizure in 1897, he quietly waited for the end. But it is no more than an outline, and though interesting as being his own account of himself, it is scarcely adequate as a lasting and final memorial of one who well deserves to be had in remembrance for his services to the geology and educational progress of Canada. Having been delayed till almost the end of his life, the autobiography lacks the freshness and fulness of recent recollection. Sir William met with many interesting and notable men in his time of whom one would fain have had his impressions—such pen-portraits as he probably gave in letters to his friends or family. One would like to know something more of his boyhood and the influences that drew him into the geological field. In a new country, before the days of railroads and coasting steamers, geological expeditions must often have brought a man into strange experiences. Then in regard to educational effort, which lay so close to Sir William's heart and to which he devoted so large a part of his strenuous life, he gives just information enough to make us long for more, that would fill in the details of an interesting struggle of which merely a sketch is given in the book. His published addresses and reports enable us to trace the general progress of his efforts, but naturally they lack the personal element, and the ordinary reader may sometimes fail to realise how much of the advance they chronicle was due to the initiation and persistent energy of the principal of McGill College himself.

Sir William Dawson's original contributions to science range over a considerable field, but the most important of them deal mainly with two departments of geology. He has done more than any other writer to make known the characters and the richness of the vegetation that preceded the luxuriant flora of the Carboniferous period. He speaks regretfully of the refusal of the council of our Royal Society to publish a paper and illustrations which he had prepared on the plants of the Old Red Sandstone, "thereby losing the credit of giving to the world the largest contribution made in our time to the flora of the period before the Carboniferous age." He adds that "a work which had cost me a large amount of time, labour and expense, and which I had looked upon as my *magnum opus*, was not adequately published and probably never will be."

The other branch of geological inquiry which Sir William prosecuted with characteristic energy related to the glacial deposits of Canada. After publishing a series of papers on the subject, he gathered up his results in more connected and popular form and published them in 1894 in his volume on "The Canadian Ice-Age." While glacialists have not generally accepted some of his views of the succession of events, they must acknowledge that recognition is due to the pioneer work by which the facts were first collected and arranged.

Allusion may be made here to another scientific question to which Dawson devoted a great deal of time and thought, though comparatively little reference to the subject occurs in the present volume. His name will always be associated with those of Logan and Carpenter in connection with the *Eozoon Canadense* of the Laurentian limestone. They regarded it as the earliest known trace of animal life, and as probably belonging to the foraminifera. Eventually their views were criticised and opposed, until now the prevailing opinion is adverse to the organic grade of the supposed fossil, but the principal of McGill College appears to have maintained his position to the end.

Sir William Dawson was an eminently religious man and a Christian of the most orthodox Presbyterian type. Though naturally peaceful, he was always ready to lay lance in rest and have a tilt with some adversary of his faith. He never accepted Darwinism. Three months after the appearance of the "Origin of Species" he published his first criticism of the modern doctrine of evolution. From that time, in articles, addresses and books, he continued to express more or less forcibly his dissent. The year before his death he summed up "The Case against Evolution," and in the autobiography which occupied his last days there are occasional indications of his unabated opposition to the opinions "as to the great instability of species, which have been so current among the leaders of the Darwinian evolution." His more popular volumes have had a wide circulation and have been of service in spreading an interest in geology and geological speculation.

The autobiography indicates in general terms that its author led a busy life, but no reader will gather from it an adequate idea of the extraordinary activity of that life. Even the ample list of separate papers which appears in the Catalogue of the Royal Society indicates only one side of his work. To that list must be added a voluminous series of lectures and papers on a wide range of educational, theological and other subjects, and quite a small library of separate books. And all this literary industry went on amid the incessant calls of an onerous official position. We trust that the autobiography may soon reach a second edition, and that advantage will then be taken of the opportunity to add such information as will hand down a fuller picture of the life and work of the late principal. A selection from his letters would be a welcome addition to the volume, likewise a list of his publications arranged year by year. Such a list, prepared by Dr. H. M. Ami, one of Dawson's pupils and a member of the staff of the Geological Survey of Canada, was published in *The American Geologist* for July 1900. It needs careful revision, but might be made the foundation of a good bibliography. Sir William took so prominent a place in his time that there must be many hundreds of his friends and pupils who, while delighted to have his autobiographical sketch, would be glad to possess a fuller memorial of the man and of his achievements in the cause of science and of education. A. G.

THE FLORA OF INDIA ILLUSTRATED.

Annals of the Royal Botanic Garden, Calcutta. Vol. ix. Part i. *A Second Century of New and Rare Indian Plants.* (Calcutta: 1901.)

WITH the exception, perhaps, of Brazil, the flora of which has been more systematically illustrated, the flora of no country of very large area is so well pictorially illustrated as that of India. Disregarding the earlier publications of less precision, there are the works of Wight, Wallich, Roxburgh, Griffith, Royle and Hooker, and, later, of Brandis, Beddome and others, to say nothing of the very numerous scattered figures of Indian plants.

In 1888 Dr. (now Sir George) King, then Superintendent of the Calcutta Botanic Garden, commenced publishing a new series of quarto illustrations of Indian plants under the title cited above. The first volume contains all the Indian species of Ficus; the second the species of Artocarpus, Quercus and Castanopsis; both by King himself. The third volume is an illustrated monograph of the Indian species of the herbaceous genus Pedicularis, by Dr. D. Prain, the present Superintendent of the Calcutta Garden. The fourth volume is devoted to the Anonaceæ, by King; and the fifth contains a century of orchids, edited by Sir Joseph Hooker, and a century of new and rare Indian plants, by King and P. Brühl. The sixth volume is of a different character, and illustrates some of the microscopic researches of Dr. D. D. Cunningham. The seventh is a fully illustrated monograph of the Bambuseæ of India, by Mr. J. S. Gamble. The eighth volume, nominally, consists really of three thick volumes and comprises 448 coloured plates of Indian orchids, by Sir George King and Mr. R. Pantling. Each of these volumes has been more or less fully noticed in NATURE as it appeared.

The first part of the ninth volume contains a second century of new and rare Indian plants, by King and Prain and Mr. J. F. Duthie, Director of the Botanical Department, Northern India. Remarkable among these novelties are five beautiful species of Meconopsis (Papaveraceæ), thus nearly doubling the number of this essentially Himalayan genus. The specific names, *grandis*, *superba*, *bella* and *primulina*, are suggestive of the ornamental characters which these herbaceous plants possess in a high degree. Unfortunately they are rather difficult to cultivate, but one or two species succeed very well in the rock-garden at Kew. Two or three very fine species of Meconopsis are among the comparatively recent discoveries in western China, and *M. horridula* is one of the most generally dispersed plants in the meagre flora of Tibet, at altitudes of 12,000 to 17,000 feet. Indeed, all the Asiatic species inhabit high levels, and some of them reach the upper limit of phanerogamic vegetation. The only outliers of the genus are *M. Cambrica*, the lowly Welsh poppy, and *M. heterophylla*, a native of California. One of the finest of the species figured in the "Annals," *M. grandis*, is only known from Jongri, in Sikkim, where it is cultivated at altitudes of 10,000 to 12,000 feet, not for its beauty, however, but for the oil obtained from its seeds. Figures are given of three other pretty Papaveraceæ, namely, *Cathcartia lyrata*, *C. polygonoides* and *Chelidonium Dicranostigma*.

From a botanical standpoint the drawings are very good, and the lithography deserves to be rated as excellent. Nearly the whole is the work of native artists.

We have made a point of the new Papaveraceæ, but there are other equally interesting subjects illustrated in this part. New Rutaceæ, Burseraceæ and Sapindaceæ, chiefly by King; Leguminosæ and Labiatæ, by Prain; and alpine Himalayan plants, including new species of Primula, by Duthie.

There is also a proposed new genus of Orobanchaceæ, concerning which particulars of its affinities might have been given. It is named *Gleadovia ruborum*, and was discovered by Messrs. Gleadow and Gamble growing on the roots of *Rubus niveus*, in fir woods, in the North-west Himalaya. The great value of such a publication as the "Annals" can only be appreciated by the working botanist, and it will be of general interest to know that plants of special economic interest will be a feature in the next part. W. BOTTING HEMSLEY.

OUR BOOK SHELF.

Essais sur la Philosophie des Sciences. Analyse, Mécanique. By C. de Freycinet. Second edition. Pp. xiii + 336. (Paris: Gauthier Villars, 1900.)

A GOOD book on the philosophical aspect of space, time, mass and force is rare. M. de Freycinet has produced a work that is both readable and worth reading. It opens with a chapter on space and time in which the essential differences of these two fundamental conceptions are discussed, and the impossibility of forming a quantitative estimate of time except by artificial means is clearly pointed out. The next chapters deal with the notions of infinity, of continuous magnitude, of limits, of infinitesimals and of differential coefficients. In considering the reality of such conceptions, the author is careful to distinguish between reality in a mathematical and in a physical sense, and to point out that reality in the first sense does not necessarily imply reality in the second. Thus the solutions by the calculus of many problems in mathematical physics are based on the assumption that both space and matter are continuous and capable of indefinite subdivision, and these solutions are none the less correct although other phenomena teach us that matter is to be regarded as built up of discrete molecules.

The second part deals with the quantities occurring in dynamics, the laws of motion, the principle of conservation of energy. In it M. de Freycinet has endeavoured in the present second edition to throw greater light on the debated question as to the relative parts played by Galileo and Kepler in the discovery of the laws of motion. According to him these laws consist of (1) the law of equality of action and reaction, due to Newton; (2) the law of inertia, now attributed to Kepler; (3) the law of independence of movements due to Galileo, according to which the relative motion of the parts of a system is unaltered by impressing a common velocity on them; and (4) the law of equivalence of work and heat due to Mayer and Joule. If this last law, which practically amounts to a definition of *heat* as a dynamical quantity, coupled with a statement of the principle of conservation of energy, is to be admitted among the laws of motion, why should the second law of thermodynamics be excluded? In chapter vii. the author discusses the possible causes of loss of energy in the universe, but he might with considerable advantage introduce something about the degradation of available energy. This principle has an important bearing on the question of the infinity of the universe and the infinity of time. A finite universe cannot have existed for an infinite time past, radiating its energy into infinite space, but as soon as the principle of degradation of available energy is assumed, a similar difficulty as to infinity of time is found in dealing with an infinite universe, all of whose energy ultimately tends to be dissipated in the form of heat, and all of whose parts tend to a common temperature.

There is thus ample room for M. de Freycinet to write a further essay on the irreversible phenomena of Nature. There is another interesting field of study which he now mentions only in a footnote on p. 43, namely the existence of imaginary quantity and the remarkable fact that the generalisation of the laws of ordinary algebra requires the introduction of only one imaginary symbol. But, as the author points out, in the present state of science it is impossible for one man to survey our knowledge of more than a limited portion of natural phenomena. M. de Freycinet has given his readers much to think about in the domains of infinitesimal analysis and rational mechanics, and, moreover, this is written in a style which makes the book easy to read.

The Thermal Measurement of Energy. Lectures delivered at the Philosophical Hall, Leeds, by E. H. Griffiths, M.A., F.R.S. Pp. viii+133. (Cambridge: University Press, 1901.)

THIS little book consists of an account of four lectures, delivered to teachers by the author, at the request of the Technical Instruction Committee of the West Riding County Council. The author remarks that "The reflection that hundreds of such teachers should have been willing to sacrifice their Saturday afternoons to the study of certain physical measurements which did not even possess the charm of novelty may somewhat lighten the gloomy prospect sketched for us by those who hold pessimistic views as to the future of Intermediate Scientific Education in this country."

In attempting to render interesting a discussion of the thermal measurement of energy, Mr. Griffiths undertook a difficult task, which he has discharged admirably. There is no trace of the "popular lecturer" pure and simple; in his treatment of the subject success is due, not to an adroit avoidance of difficulties, but to the straightforward and conscientious attention given to every point of importance. In the first lecture, a number of well-chosen experiments are used to illustrate the conversion of work into heat. The second lecture is occupied with a consideration of the first and second laws of thermodynamics; incidentally the student is made acquainted with some of the difficulties attending thermometric determinations. In the third lecture an account is given of the principal methods which have been employed to determine the mechanical equivalent of heat. In this connection students will welcome the description of Reynolds and Moorby's determination, which has not as yet been dealt with in the text-books; it is to be regretted that more space could not be devoted to this valuable piece of work. A good account is given of Mr. Griffiths' own experimental test of the validity of the system of electrical units. Lecture iii. closes with a description of the recent experimental work of Callendar and Barnes on the variation in the specific heat of water.

The fourth lecture possesses very great interest. After remarking that text-books frequently give the specific heats of the metals to four of five decimal places, it is pointed out that these results necessarily depend for their accuracy on the values assumed for the specific heat of water at various temperatures. Generally speaking, authors content themselves with referring to Regnault's results, without, however, consulting Regnault's original papers. It appears that *only two* experiments were performed by Regnault for temperatures below 107°, and these were undertaken merely to test the working of the apparatus used, and Regnault himself attached no importance to them. As a matter of fact, Regnault performed a series of determinations of the changes in the specific heat of water *over the range* 107° *to* 190° C. After discussing the results, he stated what the nature of the variation between 0° and 100° would be if deduced by extrapolation from the experimental curve obtained at the higher range. Later investigations have proved these conclusions to be at fault, so that much otherwise unimpeachable experimental work relating to specific heats requires revision, and in many cases the data necessary for this purpose are not given by the authors.

It is finally recommended that the specific heat of water between 17° and 18° C. shall be defined as of unit value; this also amounts to defining the mean specific heat of water between 0° and 100° as of unit value. In that case the most probable value of the mechanical equivalent of heat is equal to $41{\cdot}84 \times 10^6$. E. E.

Instruments et Méthodes de Mesures Electriques Industrielles. By H. Armagnat. Pp. iii+614. (Paris: C. Naud.)

FEW, perhaps, realise how much electrical engineering owes its rapid development to the ease and precision with which the measurements it needs can be made. Yet it is this which renders it so amenable to mathematical and scientific treatment, and it is very largely owing to the fact that it can be so treated that it has progressed so rapidly. The manufacture of instruments has in many instances led rather than followed the development of the engineering side of the electrical industry. The practical engineer finds ready to his hand instruments for almost every conceivable purpose he may require, and it cannot be questioned that it is of the highest importance that he should properly understand their construction and limitations. M. Armagnat's book should therefore prove exceedingly useful to such men as a work of reference in which they can find a full discussion of the principles underlying the construction of the tools they use. As the author points out in his preface, beginners, and those also who habitually use instruments, are too often ignorant of their powers and of the proper way of treating them. Many mistakes, often of a serious nature, would be avoided if this state of affairs were remedied.

M. Armagnat describes both the instruments which are only to be found in electrical laboratories and those which are in daily and extended commercial use. It is the part of the book dealing with the commercial instruments which will commend itself more particularly to the practical engineer. The author has wisely confined himself to describing typical instruments of each class, and has refrained from giving descriptions of the numerous different examples of the type. Perhaps, however, an improvement would be introduced if instruments of different makes were compared, as this would serve as a useful guide to those who are in doubt as to what to purchase most suitable for their particular requirements. Valuable information is given as to the best methods of installing delicate instruments, of securing good illumination, freedom from vibration and outside disturbance, and of carrying out observations and measurements. The chapters devoted to these subjects add very greatly to the usefulness of the book, especially from the point of view of the student. It may be said finally that the book is not merely useful as a work of reference, but it is thoroughly readable throughout. M. S.

Pleasures of the Telescope. By Garrett P. Serviss. Pp. vi + 200. (London: Hirschfeld Brothers, 1901.) Price 6*s.* net.

THIS book is the result of the collection under one cover of a series of articles originally published in serial form, after considerable revision and insertion of matter necessary to bring the information up to date.

Chapter i. deals in a very interesting manner with advice on the choice of telescopes, special characteristics of refractors and reflectors, principles underlying the achromatic corrections of refractors, and methods of testing the performance of astronomical instruments.

Following this, six chapters are devoted to a series of descriptions of the constellations, numerical particulars being furnished for all the more interesting objects. A very liberal supply of star-maps—twenty-six—serves for the identification of all the objects mentioned in the text.

The main features of the planets are also described, small cuts indicating the details to be seen with powers usually at an amateur's command. Four charts of the moon are given, showing the more important formations only, so as to avoid the confusion inseparable from the complete maps. This section is made exceedingly interesting by the various formations being compared with each other, the reader passing from one to another much more readily than by merely going over a list of objects. Users of the book will recognise the treatment of the subject as similar to that in "Astronomy with an Opera-glass," by the same author, and it will doubtless be welcome to many workers who only require information concerning objects within reach of the instruments usually possessed by amateurs; but the size of telescope catered for, of 5 inches aperture, is sufficiently large to render the information of service to the more advanced astronomer as well. There is only one slight criticism which may be suggested regarding the preparation of the star maps. On these there is no indication of either the coordinates of right ascension or declination. In actual practice, either in learning the constellations or in passing from one map to another, it is impossible to overestimate the help which is furnished by the graduated position lines. The legibility and general arrangement of the maps, however, are excellent and add greatly to the value of the book, which there can be no hesitation in recommending to the notice of all interested in observational astronomy. C. P. B.

Introductory Physics for Irish Intermediate Schools. By R. A. Gregory and A. T. Simmons, B.Sc. Pp. ix + 218. (London: Macmillan and Co., Ltd., 1901.) Price 2*s.*

THIS little book, as its emerald-green covers and title suggest, is for the use of Irish boys and girls preparing for the examination on the new syllabus in introductory physics issued by the Department of Agriculture and Technical Instruction. A glance at the book shows that Irish physics is the same as English, and those familiar with the other books prepared by the same authors will find here practically the same exercises. S. S.

Algebraical Examples. By H. S. Hall, M.A. Pp. viii + 172. (London: Macmillan and Co., Ltd.) Price 2*s.*

IT will be a convenience to many teachers to possess this collection of algebraical exercises to supplement those given in Hall and Knight's "Algebra for Beginners" and "Elementary Algebra," up to quadratic equations. The exercises are carefully graduated, and are classified so that the teacher can easily select those referring to the subject with which he is dealing. In addition, there are a number of test-papers containing miscellaneous examples to test the pupil's grasp of the principles of algebra in which he has been exercised.

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 FitzGerald-Lorentz Effect.

IN the January number of the *Philosophical Magazine* I published a discussion of the general theory underlying the experiment of Messrs. Michelson and Morley on the drift of the æther. As one result, it appeared that the effect to be expected in their special case was just the opposite of that usually supposed, and that consequently the FitzGerald-Lorentz explanation of the observed null effect would not hold. Mr. H. M. Macdonald has pointed out the source of this discrepancy in an algebraic slip in my paper; when this is corrected, the result comes into agreement with the special case treated by Michelson and Morley. The exact effect on the displacement of the interference-bands arising from a vertical component in the æther-drift has not been hitherto directly considered. It is probably null; but this requires verification, which I hope to be able to take up shortly on the basis of my analysis. As the question stands at present, the corrected result shows that the FitzGerald-Lorentz shrinkage would completely annul the shift when the drift is tangential. Although Dr. Larmor has not directly discussed the effect of an oblique drift in his "Aether and Matter," I understand from him that he has come to the conclusion (*cf. loc. cit.* § 34) that complete annulment results in all cases on the FitzGerald-Lorentz hypothesis. I think further discussion on the lines of my own method of analysis will verify that this is the case.

Meantime I send this intimation in order that others may not spend time in tracking out a discrepancy which has already been cleared up. W. M. HICKS.

University College, Sheffield, February 10.

Birds Attacking Butterflies.

ON July 22, 1901, a dull, sunless day, I pointed out to Prof. Gotch a fine fresh male specimen of the "Holly Blue" (*Lycaena argiolus*) at rest on the leaf of a shrub behind the Oxford University Museum. Touching it with my finger, the butterfly rose and fluttered feebly along the curved walk in the Parks. At that moment a swallow (or a martin) came down the walk from the opposite direction at full speed. It must have seen the butterfly fluttering towards it from a considerable distance; for with the most perfect ease and control it diverted its course and took the insect in its sweep. I felt, as I saw it, that only by good fortune was it possible thus to obtain the most direct evidence of events which are probably continually occurring.

There are, however, other means by which evidence can be obtained. One is the examination of the crops of dead birds. Although we should be sorry for British birds to be killed with this object (except in special circumstances), it is much to be hoped that the observations will be made when birds are killed, whether accidentally or otherwise. Mr. R. Newstead, of the Chester Museum, has done excellent work in this way; but there can be no doubt that, taking the country as a whole, only an insignificant proportion of the obtainable evidence is utilised.

Another line of evidence is afforded by specimens of butterflies which have their wings injured in a manner which is inconsistent with any interpretation except the snip of a bird's beak. Thus it is common to find fresh and unworn specimens with a notch or tear on the right side which exactly fits a corresponding injury on the left side, indicating that the wings had been torn when they were in contact. In one extreme instance, presented to the Hope Department by Dr. F. A. Dixey, a deep little notch had been cut out of all four wings of a "Red Admiral" (*Vanessa atalanta*), the four injuries exactly coinciding in the true position of rest adopted by this insect.

Oxford, February 2. EDWARD B. POULTON.

P.S.—Mr. W. Holland, of the Hope Department, tells me that about the middle of June 1901 he saw a swallow swoop down from a great distance and catch a white butterfly (almost certainly *Pieris rapae*) flying in front of the Museum. The bird took the insect in a single sweep and then dextrously avoided a collision, which seemed almost inevitable, with the roof of the "Glastonbury Kitchen." Directly after the seizure of the butterfly, Mr. Holland saw the wings fluttering to the ground, evidently cut through at their bases by the beak.—E. B. P.

I CAN corroborate tne statement that the house-sparrow frequently pursues and captures the large white cabbage butterfly.

Probably the kestrel preys extensively on the emperor moth, whose wings I have seen lying at the base of the small hummocks formed by the *Juncus squarrosus* on the Orkney moorlands. These tufts were much used as resting places by kestrels and hen harriers, but as neither hawk is capable of catching a bird on the wing, the moths were presumably captured while at rest.

The black-headed gull feeds on the common ghost moth. Regularly every season, during many years, I saw some half dozen or more of these gulls flying backwards and forwards, about three feet above the ground, over the grass in front of my house, hawking after the white oscillating ghost moths in the long summer twilight of a calm Orcadian evening.

W. IRVINE FORTESCUE.

7, Bon Accord Square, Aberdeen, February 3.

The Severn Bore.

IN NATURE of January 23 there is an interesting illustration of the Severn Bore, as photographed by Dr. Vaughan Cornish. If I understand the note rightly, the bore took a little more than a minute to travel 500 yards, and this gives a rate of almost exactly seventeen miles an hour at the given locality.

On March 13, 1891, Mr. T. H. Thomas, R.C.A., and I measured the velocity of the bore between a point on the right bank of the river near the King's Head Inn (which is sixty yards north of the sixth milestone from Gloucester on the high road to Newnham) and a point further up on the right bank of the river, near Denny Farm and opposite to the fifth milestone from Gloucester.

The second hands of two watches were timed exactly together, and we found that the bore reached the first observer at 10h. 24m. 45s., a.m., and the second at 10h. 27m. 48s., a.m., the interval being 183 seconds.

Measured on the six-inch ordnance map, the distance along the central line of the river is 4750 feet. The velocity was therefore $17\frac{7}{10}$ miles an hour for the part of the river observed. The river channel there is of a fairly uniform width of 250 feet.

The date chosen was that of the second highest tide of the spring equinox. At 10h. 25m. the height of the bore, above low water level, as measured by a post close to the river bank near the King's Head Inn, was 4ft. 10in. As the bore passed on, the level sank to 3ft. 4in. By 10h. 30m. the water following the bore reached a height of 5ft. 4in. At 10h. $32\frac{1}{2}$m. the height was 6ft. 4in., and at 10h. 34m. the water covered the post, the top of which was nearly 7ft. above low water level. There was thus a rapid rise of the river in the rear of the bore. As seen in mid-stream, the height of the crest of the bore seemed only about 3ft. above that of the water in front of it.

There was a gentle breeze from the north-east. Had there been a south-westerly gale blowing up stream, no doubt the phenomenon wou'd have been much more impressive, but it is of interest to record observations made under fairly normal conditions.

The rushing sound, heralding the advancing wall of water, was audible for some distance. The crest of the bore was whitened by a fringe of foam, and a good deal of spray was thrown up on the banks, where the water of the wave appeared to be higher than, and somewhat in advance of, that in the middle of the river.

A small boat in the path of the bore suffered no inconvenience beyond a slight tossing. The late Frank Buckland greatly exaggerated when he described the bore as "the greatest natural phenomenon in the British Isles," and stated that its pace was equal to that of an express train. Dr. Cornish (NATURE, vol. lxii. p. 127) estimates the velocity of the bore, on April 30, 1900, as eight miles an hour between Newnham Ferry and Denny Farm, a river distance of about nine miles. But the velocity evidently increases as the stream narrows, and, in the short portion which we observed, it will be noticed that the velocity was more than twice that estimated over the longer distance.

CHAS. T. WHITMELL.

Leeds, February 3.

Persistence of the Direction of Hair in Man.

IN "The Descent of Man," p. 19, under the heading of Rudiments, Darwin refers to the long isolated hairs seen in the eyebrows of certain individuals, as representing similar hairs in the superciliary region of the chimpanzee, baboon and certain species of macacus. An analogous phenomenon, with a different significance, found sometimes in the pectoral region in man, seems to be worth notice. I have recently examined two persons, a male aged twenty-eight and a female aged thirty-three years, both with particularly hairless, smooth skins, and each showing, at a critical point in the pectoral region, certain outstanding hairs set closely together, the former three long hairs an inch in length, and the latter two hairs an inch and a half in length. The point of interest lies in the position and direction of these few scattered hairs, which are as noteworthy, in their way, as "erratic blocks" on a level plain. In the female case the two hairs were set just over the middle of the left second costal cartilage, and they pointed persistently *upwards* towards the neck. In the male case the three long hairs were set close to the sternum in the left second intercostal space pointing persistently *downwards*. The situations of these two curious islets of hair are exactly above, on the one hand, and below, on the other, the level at which the upward chest-stream and the downward chest-stream always divide in a hairy subject. The remarkable persistence in their ancestral direction of these few "fossil" hairs, as they might be called, seems to confirm the view that if man has inherited his hairy covering from a simian ancestry it has been modified in many regions by use and habit since he inherited it. We say that a little straw shows the way in which the wind blows, and I submit that sundry stray hairs on the body of man similarly testify as to the trend of certain mechanical forces which have acted and still act upon him.

WALTER KIDD.

The Colours of Wings of Butterflies.

MR. CROFT'S letter (NATURE, January 2, p. 198) on the subject of colours of wings of butterflies raises an interesting point.

In pressing the wings of butterflies between sheets of gummed paper in order to obtain impressions for record, I have frequently noticed that in those cases where a brilliant light blue wing is to be pressed the impression usually fails to give the correct colour; in transmitted light the impression is not blue, and in reflected light the colour is patchy and of a much darker blue; for example, the blue of a *Junonia erithyia*.

I have before me a wing—inside brilliant peacock blue, purple-blue, bronze-brown, according to the incidence of the light; in transmitted light the colour is brown. The outside of the wing is brown.

Taking an impression of this wing in transmitted light the impression is brown, in incident light very dark blue and dark bronze in patches; the peacock blue fails entirely.

If a scale of this wing be examined under a low power it appears brown in transmitted light, but peacock blue (and varying shades according to position of scale on stage with reference to light) if the transmitted light be cut off and reflected light alone used.

It would appear, therefore, that this wing owed its chief colours to other causes than pigment.

W. G. B.

India, January 21.

EXPERIMENTS ON VENTILATING COWLS.[1]

THE report of the work of the cowl committee of the Sanitary Institute presents the results of the numerous experiments made by the committee in the course of upwards of twenty years of its existence—an existence unfortunately terminated by the deaths in rapid succession of all its members. The last survivor, Mr. Rogers Field, B A., M.Inst.C.E, the most active member of the Committee, died on March 28, 1900.

The committee left in manuscript more or less complete records of some seven thousand experiments on cowls and terminals, together with particulars of the arrangements for testing the instruments employed, a synopsis prepared with a view to a comprehensive report, and

[1] The Work of the Cowl Committee of the Sanitary Institute. *Journal of the Sanitary Institute.* (Edward Stanford, 1901.)

some materials for a historical introduction, but practically no actual text. The council of the Sanitary Institute did me the honour of asking me to undertake the preparation of the report. For obvious reasons, the part that I could take in such an enterprise could only be a small one; it was limited to supervising the work done by two of Mr. Rogers Field's assistants and writing an occasional general note. In doing so I have regarded the report as addressed to those interested in the scientific study of pneumatics, and have not hesitated to call attention to the points in which the action of the committee seemed to me to have missed the true scientific bearings of its work. I propose to be equally frank in what I have now to say, but I would not thereby be understood as decrying the accuracy or the value of the experiments. The study of pneumatics has remained undeveloped probably more on account of the lack of accurate experiments and accurate measuring instruments than for any other reason. The records of the cowl committee bear ample testimony to the singleness of purpose of the committee in its desire to take all precautions and bring all conclusions to the test of accurate experiment, and the records of the experiments, with the limits of accuracy clearly apparent, must always be regarded as valuable data by which to test theoretical conclusions and an honourable memorial of a worthy effort to enlarge our knowledge of a most intricate subject.

The object of the committee was to compare, by direct experiment, cowls of different type as agents for producing a flow of air when exposed to wind and for preventing downdraught. The procedure adopted was to have three long vertical tubes projecting from a weather-boarded hut, erected, by permission of the Kew Observatory committee, in the Old Deer Park at Richmond. Each tube had an air meter inserted in it to measure the flow of air; the lower end was protected from draughts by a box with a silk gauze bottom; an anemometer gave the velocity of the wind, the direction of which was also recorded. The cowl was mounted on the middle of the three pipes, and the flow through that pipe was referred to the mean of the flow through the two external pipes. The tests of downdraught were of various descriptions that need not be referred to here.

With the comparison of cowls of recognised shapes there was associated an endeavour to ascertain the effect of different modifications of the orifice of a pipe, and for this purpose a number of such modifications were constructed and examined. Such modifications, some of which were very elaborate, are called terminals.

The report is divided into six parts :—

Part i. consists of extracts from introductory papers prepared by various members of the committee or from the correspondence preserved by the committee.

Part ii. contains an account of the testing of the air meters, and will be found to give a considerable amount of information of very great practical utility concerning the action of those instruments.

Part iii. gives the results of Mr. Rogers Field's investigation of the action of the anemometers employed. The instruments principally considered are a Robinson anemometer of the standard Kew pattern and a miniature instrument of the same type with one-inch cups. The chapter does not add much to the solution of the general problem of determining true wind velocity from the reading of a Robinson instrument, but it does show what kind of difficulties a careful and conscientious experimenter is likely to meet with if he sets about using such an instrument for the determination of true wind velocity. It also shows by some very useful diagrams the relation between the wind velocity and the flow up a vertical open tube over the end of which the wind passes.

Part iv. gives an examination of the degree of accuracy with which the mean of the flow in two outside pipes can be regarded as equivalent to the flow up the middle pipe. In some ways the results of this section are the least interesting of the whole number, because the observed differences which the committee attemped to resolve must be regarded as due to local circumstances which would probably not be reproduced in a repetition of the experiments under somewhat different conditions; but they are an essential part of the work of the committee; they show the limits of accuracy of the measurements under the prescribed conditions. Probably an experimenter with long experience of a laboratory might have been content to recognise after a few experiments a certain margin of experimental error as incidental to the method, and have left the cowl results with that margin of error, or have selected conditions which gave the least experimental differences; but the committee seemed unwilling to write off an experiment as subject to a certain margin of error until it had fully probed all the causes of error.

Part v. gives the results for terminals, as defined above. The results which can best be generalised are those which are represented in the report by what are known as "hill curves," by which are to be understood curves representing results obtained from a series of consecutive experiments upon terminals varying by the gradual extension of some particular dimension.

Part vi. gives the results for cowls.

A consideration of the whole report gives rise at once to curious reflections. If an apostle of higher education were looking for an example of the importance of recondite theoretical study to matters of practice, of the necessity to practical life for the academic professor in any subject, not as an exponent of the facts of the subject, but as a student and investigator of its abstract laws, he could not wish for a better example than that furnished by this report.

The original committee was appointed to settle an apparently simple practical matter, namely, which was the best among a number of cowls exhibited at Leamington in 1876 in competition for a prize or certificate. The matter was apparently confined to the region of practice, and it was at first assumed that only a few experiments were needed to settle the points in question. Experiments were made, and the committee reported to the effect that no cowl at all was as good as any; and the award went in consequence to no cowl at all. But this did not by any means satisfy all concerned, and numerous complaints were made as to the experiments and the way of conducting them.

Thereupon the Sanitary Institute appointed Sir Douglas Galton, Mr. Rogers Field and Mr. W. Eassie—the last-mentioned was subsequently succeeded by Mr. J. Wallace Peggs—to be a committee to conduct further experiments. They set out to repeat the experiments with such precautions that their results should be accepted as final. They worked with unremitting labour and at no small expense; tested to the uttermost every instrument employed in the investigation, and analysed all the conditions that might affect the results. They acted throughout upon the apparently simple practical principle that they could find out which was the best cowl if they could find out, for a certain strength of wind, which carried most air up a three-inch or a six-inch pipe, and up to what angle of tilt it could be set in various circumstances without suffering downdraught.

It certainly cannot be regarded as a fault in the committee that the subject had not been effectively worked at by some academic professor or student of experimental philosophy curious to learn, not which cowl should have a prize, but the general laws of flow of air through any cowl. They were capable, practical men, and naturally attempted a direct experimental answer. It may be true that in nine cases out of ten the best way of getting a practical answer to a scientific question is to set practical men to find it, and that a professor of natural philosophy would spend a long time over the inquiry and return an unpractical answer. The problem attacked by the cowl committee happened to be the exceptional tenth case in which, not academic students, but practical men, spent twenty years, a period, indeed, terminated only by the deaths of the members of the committee, without arriving at practical results of the final character looked for.

As a matter of fact, the flow of air along a three-inch or six-inch tube surmounted by a cowl is a very complicated result; it is no more and no less the measure of the efficiency of the cowl on the top of the pipe than the current through a galvanometer is a measure of the efficiency of a battery cell in circuit with it. If we picture to ourselves a committee endeavouring to pronounce upon the relative merits of the battery cells of many inventors by tabulating the deflections which they produce in a galvanometer before G. S. Ohm had been led, by purely scientific researches, to the law which has been the guide in all such questions since his time, we get an exact analogy of the action of the cowl committee. Before the efficiency of the best cowl can be effectively represented by a number, it is desirable to settle what purpose the instrument is intended to serve. The production of a flow of air in a particular combination of tubes is doubtless one purpose, but there are others. Some cowls are intended to keep the rain out of a shaft; some are picturesque terminations of flues, as the Italian examples cited by Mr. Ackermann in the cowl report; all, presumably, are intended to bring profit to their makers. As regards efficiency, they might be classified according to their performance with regard to one or other of these widely different purposes, but the classification would not be strictly scientific.

To the student of theoretical science they can only be regarded as examples of apparatus for diverting the kinetic energy of the passing air to produce a flow along the pipe which the cowl surmounts, whether the flow be up or down; and the laws of transformation of the energy will most effectively describe the behaviour of the cowls from the scientific point of view. The flow along the pipe implies a certain expenditure of energy which must ultimately be derived from the passing air (in the absence of temperature difference), and the primary effect of the cowl may be estimated by the amount of energy which it takes from the wind and diverts to producing or maintaining a flow. We may call this the aëromotive force on the analogy of an electromotive force of a battery maintaining an electric flow in a circuit.

This conversion of the energy of wind into aëromotive force is in itself a very interesting subject. There is no doubt that by suitable mechanism of the windmill type (hinted at by the Archimedean screws of some revolving cowls) the wind could be made to lift through a chimney, not only air, but also, if desired, the cinders or the coals, and even the firegrate and the hearthstone itself; but the limits of effectiveness of purely pneumatic as distinguished from mechanical arrangements would be a very useful and productive subject for study. To take the matter a stage further in detail and ask whether it is possible by any combination of plane or curved surfaces to make the velocity of the air passing over the mouth of a tube greater than the original velocity of the wind, is to suggest an inquiry with important bearings upon many scientific subjects. For example, when wind blows through a truncated cone along the axis of the cone, is the velocity of emergence greater than the velocity of the unimpeded air? The cowl results do not answer this question, but indicate some suggestions. They show that a large cowl is more effective than a smaller one of similar pattern upon the same pipe; that the output of a pipe can be considerably increased by surmounting it with an extending cone-piece and adding at the widened end a "louvre" band attached by a regulated number of "feathers," and above that a cap at a certain distance. Whether this arrangement actually increases the velocity of the air passing over the mouth of a tube or merely prevents diminution only a master of theory can say. There is no experimental answer to this question.

Just as the current in a galvanometer gives no final indication of the electromotive force of a battery in its circuit, so the air current in the tube gives no final indication of the aëromotive force of the cowl. The resistances of all parts of the circuit and any accessory aëromotive forces must likewise be accounted for.

The resistances to be accounted for must refer to all parts of the complete circuit and are more complicated than electrical resistance, for they depend partly upon friction in which the loss of energy is proportional to the first power of the velocity and partly upon the turbulent motion in which the loss of energy is proportional to the square of the velocity. There are also in the circuit of flow arranged in the cowl experiments other aëromotive forces than that due to the cowl. In order to make this clear, it is sufficient to point out that the circuit consisted of the cowl, a length of three-inch pipe, an air meter, a short pipe opening into a box with a silk gauze base, and some opening, either door, or window, or chinks, between the interior of the hut where the observer was accommodated and the outside air. If the cowl had been removed the flow would not have ceased; even if the long tube were removed altogether there would be some flow through the opening, and if the opening were in the side of the hut instead of the top there would still be flow, thus indicating aëromotive forces quite apart from that due to air passing over the cowl or the top of the open tube.

The cowl committee made no inquiry into the different elements which go to make up the composite effect read on the air meter, and consequently made no attempt to analyse the effect of a cowl into the production of aëromotive force and resistance, just as the effect of a battery may be analysed into the production of electromotive force and electrical resistance. As downdraught is reversed flow, the same kind of uncertainty attaches to the results of the committee's experiments upon this branch of the subject.

The most confusing results are those for cowls used as injectors. In the case of exhaust cowls, comparison was made between the flow in three parallel pipes, the middle one carrying the cowl, the other two bare. The direction of the flow was the same in all three and all were fed from the interior of the same hut. When the effect of an injector was to be measured it was mounted upon the middle pipe, the outside pipes still remaining free. The aëromotive force in the injector pipe was, of course, reversed; one pipe supplied air to the hut and two extracted air from it. In that case flow could go on if the hut were otherwise hermetically sealed, and allowing for the hut being leaky, as it was, intentionally so, the network of currents is so complicated that it is difficult to attribute any precise meaning to the relation of the flow down the middle pipe and to that up the outside pipes, the relation selected by the committee to represent the effectiveness of the injector.

I have given some justification of the statement that the results obtained by the committee are no more indicative of the characteristic action of cowls than galvanometer readings are of the characteristics of batteries; I should like to add some words in explanation of the parallel statement that they are no less so.

If the resistances in an electric circuit are all maintained the same and the only changes introduced are successive slight modifications of the battery itself, it is quite possible to obtain from the corresponding galvanometer readings sufficiently definite information about the effect of the changes in the battery. Examples analogous to this are afforded in the report by numerous comparisons of the effect of the different aspects of what may be called polarised cowls or terminals, *i.e.* cowls or terminals the action of which is different according to their position with regard to the direction of the wind. One of the most conspicuous is that of a cowl of the same shape as the torpedo air extractor now so much in use on railway carriages. From the numbers given, the apparatus is clearly much more effective when the wind crosses the opposed cones than when it passes along the cones and through the ring, and this difference of action is definitely characteristic of the two positions of the cowl.

Towards the end of the period of its labours the committee began to approach the question in more academic or philosophical fashion. Experiments with smoke were tried to see how cowls and terminals really acted. The committee was thus led to test the effect of successive variations of the number, size, position and arrangement of different modifying elements, such as a flange at the rim of the orifice or at a measured distance from it, a set of "feathers" arranged round the orifice and "louvre" bands or caps above it. A series of experiments to test the effect of the variation of a single element was carried out on single days and the results plotted in curves for the single varying elements. Here we have as results only galvanometer readings for different batteries, so to speak, but for batteries varying only in a single particular, and from such information effective inferences can be drawn about the action of the battery. These results afford the best material in the report for the scientific study of the action of cowls. It still remains only material, and requires working up with due regard to the theoretical considerations referred to. But some practical results follow directly. For example, a flange surrounding the orifice of the pipe diminishes the aëromotive force produced by wind passing over it, and if sufficiently extended practically annihilates the flow. It is not by any means impossible that an examination of these curves may lead to further investigation of the laws of flow through tubes under the action of passing wind. It is a subject which presents all the difficulties of the corresponding electrical problems, with some added in consequence of the inertia of the moving fluid, but it is of great practical as well as theoretical importance, and the report will have done good service if it attracts attention to the further study of the subject from this aspect.

One of the most amazing facts about the history of science in the last century is the little progress made in our knowledge of pneumatics compared with the advances in our knowledge of the flow of electricity, which still borrows its language for practical purposes from the older and now almost neglected study of the flow of fluids. The theoretical development of electricity can be attributed to Faraday's experimental investigation of the laws of electromagnetic induction. The flow of air along pipes in consequence of wind passing over the top may fairly be regarded as a case of pneumatic induction. The experiments of the cowl committee, if they have not succeeded in classifying these inductive effects into laws, have reopened the study of the subject, and at least give evidence that it is not the fulness of experimental knowledge that has dissuaded the intellects of the students of our laboratories from its investigation.

W. N. SHAW.

GOLD IN INDIA.

INDIAN gold is attracting the attention of the Geological Survey of India. In NATURE for May 9, 1901, we directed attention to Dr. F. H. Hatch's report on the Kolar gold-field in Mysore. We have now received reports on the gold-fields of Wainád, by Mr. H. H. Hayden and Dr. Hatch, and on some auriferous localities in north Coimbatore, by Mr. Hayden (*Mem.* Geol. Survey, India, vol. xxxiii. part ii. 1901.) These districts lie to the south of Mysore. The extraordinary discrepancy between reports made on various properties of Wainád by mining experts and the actual results subsequently obtained have justified independent investigations on the part of the Indian Government. It is recorded that in 1880 numerous companies, having an aggregate capital of more than four million pounds, were floated on the London market; of these only three companies retain their properties, and no work has been done for a number of years. The question to be solved was whether improved modern methods might render it possible to revive the gold-mining industry in the area. Dr. Hatch's report is, however, unfavourable. Dealing specially with two mines, he finds that ore does not occur in payable quantity, and he is unable to recommend further prospecting. Mr. Hayden gives an interesting historical sketch of the gold-mines, and describes in some detail the geological features of the district. The country-rock is in most cases biotite gneiss; this has been affected by a series of parallel fissures which run obliquely to the direction of the foliation, and in these fissures the vein-material was deposited. Pyrites proved to be the chief source of the gold, but the richer ore-bodies are small irregular patches, not of sufficient extent to be of material value.

Mr. Hayden remarks that there are few auriferous areas in India, poor as well as rich, that have not at some period or other been exploited by the natives; but the fact that gold was obtained in sufficient quantity to cover the expenses and leave a margin of profit, does not in itself justify the belief that a good margin of profit would be obtained if modern methods of working were adopted. Many of the reefs were probably mined by forced labour or by slaves. Thus one of the Wainád reefs, which was, perhaps, worked more extensively than any other, has given, from nearly 200 samples, an average yield of about two pennyweights of gold to the ton of ore. In Coimbatore there are numerous old native workings for gold, but they are, as a rule, small and unimportant, and the ore-bodies are either very thin or barren. Further prospecting, however, appears to be advisable in this district.

NOTES.

THE attendance of the Prince of Wales at the meeting of the Royal Society on Thursday last is an event which we have pleasure in recording. His Royal Highness was formally admitted as a Fellow of the Society, and remained throughout the meeting. At the close of the proceedings he was invited by the president to address the meeting, and in response he said:—"Mr. President, my lords and gentlemen,—It gives me very great pleasure to have been able to come here to-day and to be formally admitted as a Fellow of this ancient and distinguished society. But, as you conferred the honour of Fellowship upon me some eight years ago, I really ought to apologise for not having presented myself before. I can only say I am indeed proud that my name should be added to those on your illustrious roll, which has been inscribed by nearly every Sovereign since the reign of Charles II., and by all the most distinguished men of science since those days, such as Wren, Newton, Davy, Faraday, Darwin, and many others. I would wish to offer my sincere thanks to Sir William Crookes for his most interesting lecture, which I am sure we have all listened to with great pleasure. If I may be allowed to do so, I should like to congratulate him on his power of treating such an abstruse question (for I must confess that the title rather alarmed me) so as to make it intelligible and attractive to those who, like myself, unfortunately cannot lay claim to much scientific knowledge. But, while fully realising how far beyond my reach this knowledge lies, I can assure you of my hearty sympathy with that scientific study and research, which now, more than ever, has become so important an essential in our national life."

AT the annual general meeting of the Royal Astronomical Society, to be held to-morrow, February 14, the Society's gold medal will be presented to Prof. J. C. Kapteyn, of Groningen, Holland, for his work in connection with the Cape Photographic Durchmusterung and his researches on stellar distribution and parallax. The Jackson-Gwilt (bronze) medal and gift will be presented to the Rev. Thos. D. Anderson, of Edinburgh, for his discovery of Nova Aurigæ and Nova Persei.

THE first afternoon meeting of the Chemical Society will be held on Wednesday next (February 19) at 5.30 p.m. Among the papers to be read are two on "Enzyme Action," by Prof. Adrian Brown, of Birmingham, and by Dr. Horace Brown, F.R.S., and Mr. Glendinning, and one entitled "The Union of Hydrogen and Oxygen," by Mr. H. Brereton Baker.

WE learn from *Science* that the Johns Hopkins University will celebrate its twenty-fifth anniversary on February 21 and 22, when President Remsen will be formally inaugurated. Dr. D. C. Gilman, president emeritus, will deliver a commemorative address on February 21, and President Remsen will give his inaugural address on the following day.

THE fall of red dust described by Sir Edw. Fry in last week's NATURE (p. 317) appears to have been observed over a wide area. Mr. F. H. Perry Coste sends us a cutting from the *Cornish Times* of February 8, in which it is stated that remarkable showers occurred over a large part of Cornwall during the latter part of January, the rain holding in suspension a fine dust, variously described as ranging from yellow or sandy-colour to whitish or brick-red. At Liskeard the deposit is spoken of as yellowy-red in colour; at Menheniot it had the appearance of brick-dust; at Calstock the deposit left by the rain was like fine yellow mud or sand; while, among other places in this neighbourhood, the dust attracted attention at Callington, Gunnislake and Altarnun.

THE Toronto correspondent of the *Times* writes that the Canadian Government regard with much satisfaction Mr. Marconi's recent success in signalling across the Atlantic. We rather question whether the results as yet obtained justify the hopes which seem to have been raised for a speedy establishment of cheap telegraphic communication between Canada and the mother country. More reasonable is the idea of utilising the system to its full in order to assist navigation at the mouth of the St. Lawrence. Canadian commerce, it is pointed out, will greatly depend in the future on the development of the St. Lawrence route, and there can be no question that navigation of the Gulf of St. Lawrence and the coast of Newfoundand would be much aided by a system allowing for communication between ship and ship and ship and shore.

THE Paris correspondent of the *Times* announces the death, at the age of seventy-two, of Mme. Clémence Royer, who first became known to the French reading public by her translation, in 1862, of Darwin's "Origin of Species." To this translation she prefixed what is regarded as one of the most famous essays in contemporary French thought. She was the author of "Le Bien et la Loi Morale" (1881) and of "La Constitution du Monde" (1900), and numerous original memoirs on archæology and anthropology. In 1895, MM. Berthelot, Aulard, Th. Ribot, Ch. Richet, Letourneau and Levasseur solicited for her the Cross of the Legion of Honour, alluding to her thus:—"Savante et philosophe d'une valeur rare c'est une des illustrations féminines de ce siécle." This decoration was not given her, however, until 1900, when the Minister of Education, M. Leygues, officially bestowed it at a banquet organised by Mme. Clémence Royer's Breton compatriots.

THE death is announced of Mr. William Martindale, the well-known pharmacist. From an account of his career in the *Pharmaceutical Journal* we learn that Mr. Martindale was born near Carlisle in 1840. In conjunction with Dr. W. Westcott he produced the very successful work entitled "Extra Pharmacopœia," which is highly appreciated by both physicians and pharmacists. For ten years (1873–1882) he was a member of the Pharmaceutical Society's board of examiners for England and Wales. In 1889 he became a member of the Society's council, in 1898 he was elected treasurer of the Society, and the following year he became president. He was president of the British Pharmaceutical Conference on two separate occasions; he was also a member of the council of the Royal Botanic Society, and interested himself in a scheme for the improvement of botanical teaching in London. In addition, Mr. Martindale was a Fellow of the Chemical Society, the Linnean Society, and a member of the Sanitary Institute and the Society of Arts. His position as a prominent pharmacist was recently indicated by his appointment as a member of the Privy Council's poisons committee.

A SHORT account of the results of the census of 1901 in France is given in *La Geographie* by V. Turquan. The population in each department is compared with the returns of 1801 and 1896, and the changes clearly shown by means of charts. It appears that between 1896 and 1901 twenty-eight departments show an increase averaging 25,200 each, if that of the Seine be included, or 16,000 if it be omitted, while fifty-nine departments show a decrease averaging 6000 each, a result indicating the movement of the rural population to the towns. The greatest per cent. increase is around Paris, in the departments of Nord and Pas de Calais, and along the shores of the Mediterranean; and the greatest decrease is in the basin of the Garonne, the department of Lot heading the list with a decrease of 6·1 per cent.

DR. H. FRITSCHE, director of the Pekin Observatory, has published the results of his investigation of the daily period of the elements of terrestrial magnetism, for the winter and summer seasons, based upon Gauss's general theory, and the hourly observations of twenty-seven places comprised between latitudes 80° N. and 56° S. This is the fourth work by the same author on the determination of the magnetic elements. The observations used have been collected partly from original publications and partly from those contained in the German *Meteorologische Zeitschrift*. The means are calculated from *all* the observations, including days of magnetic disturbance. Dr. Fritsche gives a detailed explanation of the formulæ employed.

THE current number of *Knowledge* contains an interesting note by Sir Samuel Wilks, F.R.S., on the history of Fahrenheit's thermometer, which, he states, owes its origin to the invention of a thermometer by Newton, described in the *Philosophical Transactions* for 1701. Newton's instrument was a tube filled with linseed oil, the starting-point being the temperature of the human body, which he called 12 (the duodecimal system being then in use); he divided the space between this and the freezing point into twelve parts, and stated that the boiling point would be about 30°. Fahrenheit, not finding the scale minute enough for his work in using Newton's instrument, first divided each degree into two parts and made it measure 24 instead of 12. Finding he could obtain a lower temperature than freezing by mixing ice and salt, he took this for his starting point, and counted 24 degrees up to body heat, making 8 freezing point and calling boiling water 53. Later on he divided each degree into four parts; it will be seen that if the last-mentioned numbers are multiplied by four, we have the thermometer which is now in use.

A YEAR ago the Scientia Club of Paris gave a dinner in honour of Prof. E. J. Marey, the eminent French physiologist, whose work has disentangled the intricacies of many animal motions. At the close of the banquet, Prof. Marey's numerous colleagues, friends and pupils expressed the desire to give tangible testimony of their admiration of his scientific achievements,

FIG. 1.—M. Marey in his laboratory. Reverse of medal.

and eventually it was decided to present him with a commemorative medal. This souvenir was engraved by Dr. Paul Richer, and the accompanying illustrations from *La Nature* show its remarkably fine character. The presentation was made to Prof. Marey at a meeting held at the Collège de France on January 19. M. Leygues, Minister of Public Instruction and Fine Arts, occupied the chair, and a large number of eminent men of science and other representatives of learning were present. M. Gaston Paris, administrator of the College, gave expression to the feelings of those who had combined to show their admiration of Prof. Marey's contributions to the study of physiological actions; and he was followed by M. Franck, one of Prof. Marey's old pupils, who described the work of his master. M. Chaveau spoke as an old and close friend, and M. Leygues, after referring to the chief characteristics of Prof. Marey's researches, remarked in conclusion:—"Je prie Monsieur Marey, au nom du gouvernement de la République, dont je suis ici le représentant, d'agréer l'hommage de sa reconnaissance et de sa respectueuse admiration." Letters and telegrams of congratulation were received from many physiologists unable to be present at the meeting; and Prof. Marey replied in appropriate terms of thanks to the numerous expressions of regard of which the medal which has been presented to him is a token.

REFERRING to the experiment described by Mr. F. Hodson in last week's NATURE (p. 319), Mr. J. D. T. Morris writes from the East London Technical College to say that it is possible to produce both kinds of electrification in sealing-wax by rubbing it with silk. As with the glass rubbed with fur, gentle rubbing produces positive electrification and more vigorous rubbing produces negative electrification. The change is probably due to difference of temperature of the surface of the material used, caused by the varying amount of energy used in the friction.

A NEW monthly journal has just been started at Florence, bearing the title *La nuova Rassegna tecnica internazionale.* It contains abstracts of important papers on engineering and applied science, a summary of current literature in this region, both Italian and foreign, notices of books, of exhibitions, prizes, vacant appointments and congresses. In the present number, projected railways and automobiles receive a fair share of attention. The *Rassegna* should be useful in giving a synopsis of the most important topics of the day in connection with practical engineering.

SOME interesting details relative to trials with secondary batteries for electric traction on branch lines of railway in Germany are given in the issue of the *Centralblatt für Accumulatoren- und Elementenkunde* for December 15, 1901. These trials were instituted in 1898, after a special form of Planté cell had been devised for the particular work. The negative plates of the cells were found in actual use to have a shorter life than the positive plates, and it was necessary to take these out and to repaste them after they had done duty for 30,000–40,000 km. The batteries were carried under the seats of the carriages, and weighed fifteen tons; while the complete weight of a carriage, with its motor equipment and complement of 112 passengers, was fifty-three tons. Two of these larger carriages and two smaller ones, with accommodation for sixty-eight passengers, were built, and were regularly run on branch lines connecting the following towns in the Palatinate:—Ludwigshafen Neustadt, Worms, Schifferstadt, Landau and Amweiler. The normal speed at which these carriages were run was one of 45 km. per hour. The total cost of the larger carriages was 2750*l.*, the electrical equipment representing 1625*l.* of this total. The running costs are stated to have been 27·5 pfg. per car kilo-

FIG. 2.—M. Marey, Member of the Institute of France. Face of medal.

metre when generating charges were included, and only 21 pfg. when the batteries were charged at the central lighting station—presumably in Ludwigshafen. The corresponding charge for steam traction is stated to be 28 pfg. In the light of these trials the use of accumulator traction on short branch lines of railway, is considered to be practicable and economical.

PROF. HOLBORN, of the Reichsanstalt, Berlin, has designed a new form of electric resistance laboratory furnace, which permits temperatures up to 1500° C. to be attained with ease by use of the ordinary 110-volt electric supply. These furnaces are made in two forms, the first being adapted for heating crucibles and the second for heating tubes 44 cm. in length. Both forms of furnace are alike in principle, the electric current being conducted through a resistance coil of platinum or nickel wire, wound round a thin porcelain tube or cylinder. The crucible or substance to be heated is placed within this latter, and the space between the outer side of the coil and the containing vessel is packed with asbestos or powdered quartz. Using nickel, the temperature of the furnace cannot be raised above 1000° C. without damage to the coil, but with platinum it is possible to attain a temperature of 1500° C. with a current of 14 amperes and 110 volts. It is necessary in the use of these furnaces to include a resistance in the circuit and to use only one-half of the maximum current when the heating is first commenced. The use of exterior resistance enables the temperature of the furnace to be regulated with ease, within somewhat narrow limits. Further advantages claimed for these furnaces are—that the separate portions are replaceable when worn out, that the heating spirals can be easily removed and changed to suit the special temperatures required, and that with the tube form of furnace, the heating of the substance can be carried on in the absence of air and in the presence of any desired gas or gaseous mixture. It would be interesting to know whether any attempts have been made to apply electrical resistance heating, to organic combustion work. The usual type of gas-heated combustion furnace is capable of improvement, and the substitution of electricity for gas would bring with it some notable advantages. In localities where the day supply of electricity is at reduced rates, this application is worthy of attention.

THE climate and artesian waters of Australia form the subject of an essay by Mr. J. P. Thomson (Queensland *Geographical Journal*, vol. xvii. No. 2, 1902). The author maintains that the great central basin of Australia, as well as certain valleys within the area, are hemmed in by ancient crystalline, Palæozoic and Mesozoic rocks of an impervious character; and that during the Cretaceous period the valleys were filled up and the level of the central basin raised by detritus from the adjacent mountain ranges. Thus extensive beds of sand and gravel were spread out, and these were followed by a deposition over the central area of fine clays and shales. The clays to a certain extent seal up the water which is held in the Cretaceous sands and gravels, and thereby a good source of artesian water is provided. Since his paper was printed, Mr. Thomson announces (*Brisbane Telegraph*, December 28, 1901) that the existence of an abundant supply of good drinking water has been proved at a depth of 30 feet in the Eucla district north of the Great Australian Bight. This discovery indicates that inland settlements may be feasible in tracts which furnish good indigenous bush feed for cattle, but have hitherto been regarded as drought-stricken.

WE have received a copy of a paper by Mr. P. Frandsen, published in the *Proceedings* of the American Academy (vol. xxxvii. No. 8), on the effects of directive stimuli on slugs. It appears that, as the result of previous experiments, it has been stated that when slugs are placed on an inclined plane of glass, some move in an upward and others in a downward direction. One of the objects of the author's investigations was to test the truth of this statement, and, if true, to find a reason for the diversity of habit.

IN his presidential address to the Edinburgh Field Naturalists' and Microscopical Society, which appears in the *Transactions* for 1901, Mr. W. C. Crawford gives an interesting account of the ant-colonies shown in the Paris Exhibition, and suggests that similar exhibits might with advantage be introduced into this country. In the same volume, Mr. T. Speedy gives some interesting notes on the life-history of the badger, while Mr. A. A. Pinkerton discourses on the habits of the mole. In the course of his paper the former gentleman states that it is a common belief that young badgers do not suckle till a considerable time after birth.

SPECIAL interest is attached to Mr. R. Quick's paper on "Human Bone Instruments" in *The Reliquary and Illustrated Archaeologist* (vol. viii. January, 1902, p. 28), as the figures which illustrate it are from specimens in the Horniman Museum. It will be in the memory of our readers that this really remarkable museum was given last year by Mr. Frederick John Horniman, M.P., to the London County Council to be freely open to the public. In Mr. Quick's somewhat discursive paper an interesting series of three Tibetan drums is figured; the first is made of two human calvaria fastened back to back so as to form a sort of hourglass-shaped instrument, two knotted strings constituting the clappers. Another specimen is a brass model of two calvaria, and the third is a wooden one yet more conventionalised. Trumpets made from the thighbones of lamas and a lama's skull cap used as a drinking vessel are also illustrated.

A GOOD deal of untrustworthy theorising has been applied to textile markings found on the pottery of primitive peoples; Mr. W. H. Holmes has a careful, discriminating paper on this subject in the *American Anthropologist* (iii. 1901, p. 397). He finds pottery so marked can be divided into five classes: (1) Impressions from the surface of rigid forms, such as baskets; (2) Impressions of fabrics of a pliable nature, such as cloths and nets; (3) Impressions from woven textures used over the hand or over some suitable modelling implement; (4) Impressions of cords wrapped about modelling paddles or rocking tools; (5) Impressions of bits of cords or other textile units, singly or in groups, applied for ornament only and so arranged as to give textile-like patterns. In addition we have a large class of impressions and markings in which textile effects are mechanically imitated. Those who are interested in our own prehistoric pottery should study Mr. Holmes' paper.

A NEW volume of *The Geographical Journal*, containing the numbers published in the latter half of last year, has been received. Among the papers in the volume we notice the following as of wide interest:—Sand-waves in tidal currents, by Dr. Vaughan Cornish; the Antarctic voyage of the *Belgica* during the years 1897, 1898 and 1899, by Mr. H. Arçtowski; the anthropogeography of Argentina, by Dr. F. P. Moreno; the National Antarctic Expedition; and the lake-level of the Victoria Nyanza, by Mr. E. G. Ravenstein. There are in addition a number of papers on explorations, accompanied by maps, and the usual monthly record of progress in the knowledge of geography.

MESSRS. SANDERS AND CROWHURST have sent us for examination a number of brilliant lantern slides of birds and other zoological subjects. Photography has been a helpful handmaid to many branches of science, but none of its performances are more widely appreciated than those in the field of natural history. Drawings of animals may have artistic merit, but they do not inspire the feeling of life which is conveyed by good photographs of objects in their natural surroundings. The lantern slides sent by Messrs. Sanders and Crowhurst are from photographs of birds, nests, eggs and young and other living animals taken by Mr. Oliver G. Pike. To lecturers on natural history such true pictures of living creatures must be invaluable, and no better source of encouragement to study nature could be desired. By the side of such beautiful photographic pictures as are now available for projection upon a screen or for the illustration of books, the drawings which did duty in natural history instruction seem but a vain show. Messrs. Sanders and Crowhurst send us with their slides an ingenious arrangement for viewing lantern slides under a low magnifying power. The arrangement, though simple, is very effective, and a pleasant half hour can be passed by using it to look at lantern slides.

THE additions to the Zoological Society's Gardens during the past week include a Greater Vasa Parrot (*Coracopsis vasa*) from Madagascar, presented by Lady Amherst of Hackney; a Black-footed Penguin (*Spheniscus demersus*) from South Africa, presented by Lieut. F. J. Mosely; a Black-headed Gull (*Larus ridibundus*), European, presented by Miss M. Hall; a Bataleur Eagle (*Helotarsus ecaudatus*) from Lagos, presented by Mr. J. Peacock; two Yellow-cheeked Amazons (*Chrysotis autumnalis*) from Honduras, two Wall Creepers (*Tichodromus muraria*), European, deposited.

OUR ASTRONOMICAL COLUMN.

DISTURBANCE OF CORONA IN NEIGHBOURHOOD OF PROMINENCES.—Prof. C. D. Perrine, who had charge of the expedition to Sumatra organised by the staff of the Lick Observatory to observe the total eclipse of the sun on May 18, 1901, gives in his report a preliminary description of the results obtained in the *Astrophysical Journal*, vol. xiv. pp. 349-359. From a short examination of the photographs of the corona obtained with the forty-foot and Floyd telescopes (which are stated to show the details of the inner corona very perfectly in spite of the presence of clouds during the exposure), there is distinct evidence of disturbances in certain areas of the coronal structure. Especially noticeable is a conspicuous series of coronal hoods surrounding a prominence in position angle 115°, and also an unusual appearance in the north-east quadrant of the corona. This latter is near position angle 65°. Close to this point on the limb there is a small compact prominence, surrounding which the disturbed area has a form roughly resembling an inverted cone of large angle. The apex of this area is not visible, appearing to lie below the chromospheric layer showing at the limb. From the apparent position of the apex, a number of irregular streamers and masses of matter radiate as if propelled by some explosive force. A long thread-like prominence to the south of this point appears to originate from the same source. Above and around this region the corona is composed of broken irregular masses, very similar to those depicted on the photographs of the Orion and other nebulæ.

A NEW SOLAR THEORY.[1]

IT is a remarkable fact that in the numerous theories which have been propounded in explanation of the periodic changes of the solar phenomena no account has yet been taken of so important an element as the light- and heat-absorbing envelope surrounding the photosphere. The attention which this so-called solar atmosphere has hitherto received, on the part even of our most eminent investigators, in connection with the economy of radiant energy on our luminary, is utterly disproportionate to the importance of the subject. In spite of the fact, which was first accurately established by Langley's observations and was afterwards confirmed by others, that the sun, if deprived suddenly of this protecting screen, would radiate into space as much as double its present amount of energy, solar physicists failed to perceive that changes in the absorptive power of this envelope must entail consequences of the most far-reaching character with respect to the thermal conditions on and in the sun. That such changes—and these, too, of no inconsiderable magnitude—must inevitably occur is a conclusion which it is hardly possible to evade when it is remembered that the supreme control over the dispensation of solar energy depends entirely on a thin, shallow surface-layer, the matter of which is constantly tossed about by vehement eruptions and acted upon by a most complicated and powerful system of convection currents to and from the sun's centre.

The possibility of variations of the opacity of the solar atmosphere was, it is true, strongly urged, more than twenty years ago, by one of the greatest authorities on this question. Shortly after his well-known researches into the absorbing faculty of the solar envelope, Langley pointed out the decisive influence on the sun's radiation into space caused by changes in the transmissive power of its atmosphere. But his attention was at the time solely directed towards their probable effects on the temperature of our own planet. He found that an increase of absorption by as much as 25 per cent. would diminish the mean surface temperature of our globe by 100° F., whilst a like diminution in the solar envelope would produce a corresponding change in the opposite direction.

Now if the influence of a change in the absorptive power of the solar atmosphere is so enormous on a planet at a distance of almost a hundred millions of miles, of what inconceivable importance must it not be for the sun itself? Drawing the very natural inference that a *deficit* of outside radiation means a *surplus* of energies working upon the solar matter, and *vice versâ*, we are forcibly led to conclude that even slight changes of opacity, such as would elude our most refined observations, are bound to greatly influence the state of thermal equilibrium on our luminary.

Hence, if changes in the absorptive power of the sun's atmosphere exist, as cannot but be the case, the question presents itself: What happens with those energies which, by a condensation of the solar envelope, are prevented from escaping into space? No doubt they are preserved to the sun, but in what form? Do they raise the temperature of the solar mass, or augment its store of potential energy, or have they a share in the generation of those marvellous dynamical displays which we perceive in periodic succession on the solar surface? Questions such as these must tend to convince the investigator that a research into the causes of the variability of the forces which we see acting on the sun, if not identical with, is at least closely akin to, the investigation of the origin and the physical properties of the sun's atmosphere. I shall endeavour, in these columns, to demonstrate the possibility of such changes in the density of the solar envelope as would lead to alterations of the thermal conditions of the sun's mass, and shall make an attempt to answer the question as to how far these changes must be conducive to variations in the dynamical phenomena at the sun's surface.

There is perfect unanimity amongst astronomers as regards the nature of the force which by a continuous generation of heat compensates for the loss of energy into space. Helmholtz's theory, which attributes this heat-generation to the progressive contraction of the solar mass as a consequence of gravitation, may be regarded as one of the most probable hypotheses ever propounded in the history of physical science. But this theory does not yet enable us to form an idea of the evolution of a celestial body. It explains the existence of a heat-generating force within the star's bulk, but it gives no answer to the question as to whether the loss of energy by radiation is exactly compensated for by the generation of energy through contraction, or whether the conditions of contraction peculiar to the sun may not perhaps produce *more* or *less* heat than is required for compensation. It is, indeed, inconceivable that the conditions of contraction can remain the same throughout the lifetime of a star. The spectroscope has revealed the fact that the photospheres of different stars exhibit widely different stages as regards temperature. There are doubtless suns hotter than ours, and others considerably cooler. And we may confidently assume that the various conditions of temperature now recognised in the different types of star-spectra represent the phases which successively appear in the evolution of each of these bodies from its origin as a far-extended nebula down to its complete obscuration. In the life of each of these stars there will be a period when its temperature is on the ascent, and when, consequently,

[1] Abstract of a paper in *Astr. Nachr.* (No. 3723-24): "Ueber eine neue Theorie zur Erklärung der Periodicität der solaren Erscheinungen."

the heat-generating effect of the contractile force exceeds the loss by outward radiation, as well as another period when the declining temperature of the star indicates an excess of the heat-dissipating over the heat-producing forces. Which of these conditions, at the present moment, prevails on our sun can so far be only a matter of conjecture. In this respect, therefore, an assumption has to be made. The following inquiry applies to the case of a star on which the generation of energy by contraction falls short of the loss of energy by radiation. Whether the results of this investigation may be applied to the case of our sun must, then, depend on the further question whether the sun really belongs to those stars the temperature of which is declining. So far as I know, this latter opinion is at present held by the great majority of astrophysicists.

If on a star the loss of energy exceeds the production, the kinetic energy of its molecules, and consequently its absolute temperature, must decrease. Hence if the temperature of a layer, a_n, at a certain distance, ρ_n, from the centre was T_1 at the epoch t_1, it will be T_2 at a later epoch t_2, where $T_2 < T_1$. Now let a_1 be the level of the photosphere—or the level of maximum incandescence, and therefore also of maximum radiation—at the epoch t_1. In consequence of deficient contraction the temperature of this layer must decrease, and the materials composing it must cool down, so that, at the subsequent epoch t_2, the level of maximum incandescence will have shifted towards a layer, a_2, nearer to the star's centre, where the temperature is still sufficiently high to maintain the incandescent state of all the particles. The space between a_1 and a_2 will then be occupied by particles in a less luminous state which act as an absorbing screen on the radiation emanating from a_2. Whatever fraction of the total radiation which originally left the photosphere at a_2 is thus stopped in its outward progress will be in part absorbed by, and in part reflected from, the intervening particles of the layer a_1a_2, and there can be no doubt that some at least of this arrested energy will ultimately be thrown back to a_2 from which it started. The layer a_1a_2 must therefore act on the photospheric radiation in the same way as do our atmosphere and its clouds on the radiation from the soil. We are quite familiar with the fact that clear nights are, as a rule, cooler than cloudy ones, and we explain this phenomenon by the assumption that on clear nights radiation from the soil into space goes on more freely than when clouds offer an effective impediment to the dissipation of radiant energy.

We conclude, then, that the progressive cooling of the star leads to the formation of an absorbing envelope above its photosphere, by which the disproportion between the generation and loss of energy is reduced. But if, under the conditions at the epoch t_2, the amount of energy actually radiated into space still exceeds what is produced by contraction, the photosphere will move to a_3, still nearer to the centre, and the quantity of absorbing matter in the layer a_1a_3 will be further increased. Now although a_3 emits the same quantity of energy as did a_2 and a_1 at the former epochs, the total amount of radiation emerging into space must, at the epoch t_3, be less than it was at t_2 and t_1. Thus the opacity of the cooled atmosphere gradually increases as time goes on, and the total radiation of the star becomes less and less. Since no force is present to interfere with the cooling of the layers $a_1, a_2 \ldots$, a moment t_n must eventually be reached at which the photosphere at a_n, through reflection from all the layers above it, receives back so much of its radiation that its total expenditure of energy is exactly counterbalanced by the energy contributed by the contractile forces.

This result appears to be of eminent importance. For it shows that even on a star with deficient contraction the *exact* compensation of the loss of energy may still be possible from a certain layer downwards. This state, so exceedingly important for the conservation of energy within the star, is brought about by the progressive cooling of its superficial layers, which thereby increase their power of absorption and thus offer a more and more effective check to the radiation from the incandescent layers below.

Here, now, we are confronted with a question which leads us at once to the principal object of this inquiry: Can the state of thermal equilibrium thus eventually attained by the layer a_n be permanent? The answer is clearly negative. For when a_n has arrived at this state, none of the layers $a_1, a_2 \ldots a_{n-1}$ outside a_n have reached the same condition. Their cooling is bound to go on, and consequently their ability to absorb and reflect the heat emanating from the layer a_n must still further increase even after the establishment of thermal equilibrium at a_n. But, owing to this increasing amount of reflection towards it, the layer a_n will now dissipate even *less* energy than is required for the maintenance of thermal equilibrium, and therefore must become *overheated*. It thus comes to pass that, while the function of the absorbing envelope is that of reducing as much as possible the waste of energy from the photospheric layers, it is, by the very nature of this process, compelled to *overdo* its work, and to preserve finally too much energy within the star.

Now by this gradual overheating of the inner layers the vertical temperature-gradient must increase more and more, until it reaches a degree of steepness at which the permanence of a mechanical equilibrium becomes impossible. In such a case the overheated gaseous matter will force its way outwards and will break through the "cloak" of absorbing elements above it. But the overheated matter will not at once obey its molecular impulse to escape into higher levels. We must remember that there exists a powerful system of convection currents between the interior and the surface of the sun, and that the overheated particles may for some time be swept along the paths of these currents and may thus be forcibly detained in levels inconsistent with their increased temperature, so that their state of equilibrium is rendered unstable. This will produce a tension which increases in course of time until the upward tendency of the overheated particles becomes strong enough to overcome the resistance of the currents. At such a critical moment even a slight disturbance will be sufficient to induce the upward motion so long restrained, thus giving rise to a solar eruption. The cause of a solar outburst is therefore to be found in the temporary existence of an excessively great vertical temperature-gradient caused by progressive cooling of the outer atmospheric layers and the ensuing overheating of the inner photospheric layers.

From this exceedingly simple principle we are able to deduce an analytical demonstration of the periodicity of solar phenomena which explains all the characteristics of the sunspot curve hitherto observed. Obviously, the problem consists in demonstrating the changes in the amount of outward radiation which are caused, on the one hand, by the increase of absorptive power of the atmosphere in consequence of its progressive cooling, and, on the other, by the reduction of absorptive power of this same atmosphere in consequence of the "clarifying" action of eruptions which, by breaking through the "veil," diminish the number of cooled absorbing elements at the localities of eruption. I shall not enter upon this part of my investigation in the present note beyond stating that it is a simple application of Bouguer-Lambert's formula for the extinction of light and heat in an absorbing medium. The energy ϑ of the radiation leaving the upper limit of the atmosphere is found by the differential equation

$$\frac{d^2\vartheta}{dt^2} + \alpha\frac{d\vartheta}{dt} - \alpha\beta\vartheta = o,$$

where t denotes the time reckoned from the moment when the photospheric layer a_n has attained its state of thermal equilibrium, and α and β represent constants, the former of which depends on the rate of cooling of the atmosphere, the latter on the action of the eruptions. The integral of this equation will thus give us the changes in the radiating power of the sun towards a point in the universe. Considering that the intensity of the dynamical phenomena at the solar surface must depend on the excess of energy preserved to the sun beyond what he requires for the maintenance of thermal equilibrium at a_n, we arrive at the following theoretical equation for the frequency of eruptions and spots:—

$$r = a\left[1 - e^{\lambda_1 t} + \frac{e^{\lambda_1 p} - 1}{1 - e^{\lambda_2 p}}\left(1 - e^{\lambda_2 t}\right)\right]$$

where p is the period and

$$\lambda_1 = -\tfrac{1}{2}\alpha + \sqrt{\tfrac{1}{4}\alpha^2 + \alpha\beta}$$
$$\lambda_2 = -\tfrac{1}{2}\alpha - \sqrt{\tfrac{1}{4}\alpha^2 + \alpha\beta}.$$

It is readily seen that r starts from zero at the moment $t = o$, and that it reverts to zero at the moment $t = p$. Between these two moments r attains a maximum, and we find the time when this occurs from the equation

$$e^{(\lambda_1 - \lambda_2)t_m} = \frac{\lambda_2}{\lambda_1}\frac{1 - e^{\lambda_1 p}}{1 - e^{\lambda_2 p}}.$$

Now it can be shown that the right-hand side of this equation is under all conditions $< e^{(\lambda_1 - \lambda_2)\frac{p}{2}}$, and this the more so the greater the difference between λ_1^2 and λ_2^2. Hence we deduce $t_m < \frac{1}{2}p$; *i.e.* the ascent from zero to the maximum must take place in an interval of time shorter than half the period. This constitutes the first theoretical proof of the well-known property of the observed spot-curve that the ascent is steeper than the descent.

To give some idea of the accuracy with which the above theory can be made to represent the observed facts, I subjoin a plate (Fig. 1) in which the spot-curve, resulting from theoretical considerations, is compared with Spörer's curve derived from observation. A full description of the method by which the theoretical curve has been obtained will be given in a paper shortly to be published as part of the first volume of the *Annals* of the Royal Observatory, Edinburgh.

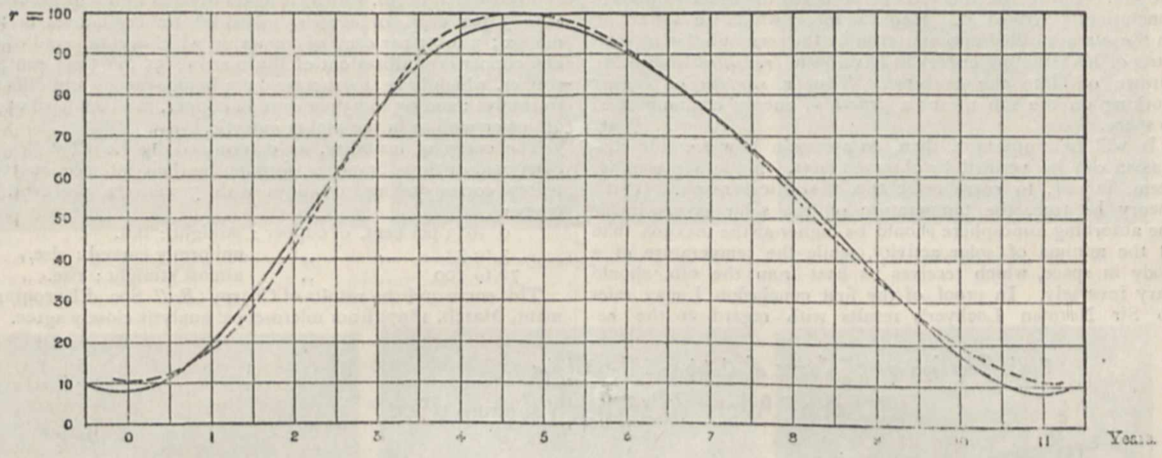
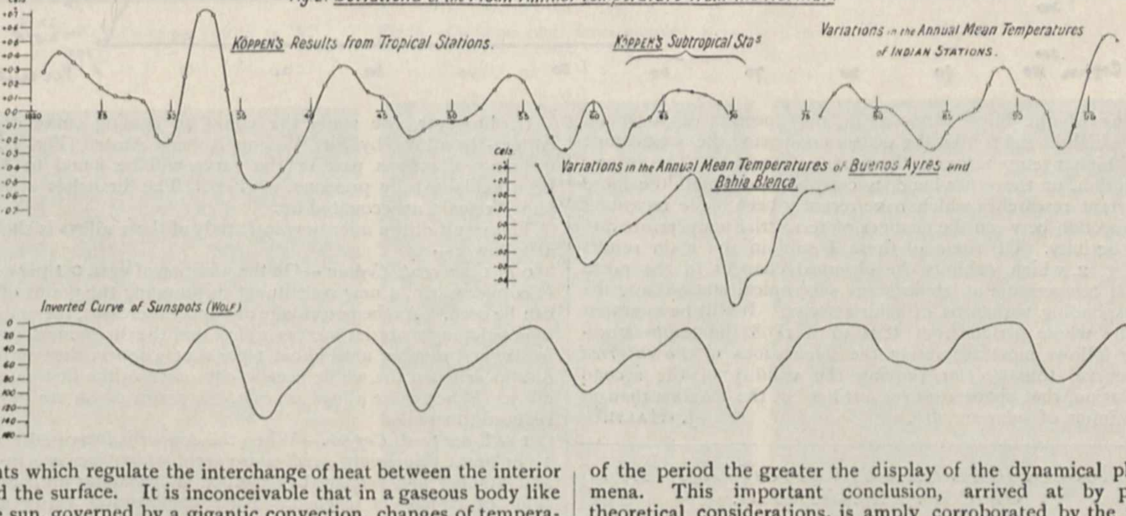


FIG. 1.——Theoretical curve of solar spots. . . . . . Observed curve of solar spots (Spörer).

The theory also accounts satisfactorily for the existence of a "great" period of solar phenomena. This greater cycle is brought about by the influence of the surface fluctuations of temperature described above on the intensity of the convection currents which regulate the interchange of heat between the interior and the surface. It is inconceivable that in a gaseous body like the sun, governed by a gigantic convection, changes of temperature of parts of its mass can be confined merely to the surface. Hence we must conclude that the distribution of temperature throughout a considerable part of the sun's bulk will be more or less affected by the fluctuations of temperature at the surface, and that consequently the intensity of the system of convection-currents, which depend on this distribution of temperature, must undergo variations similar to those exhibited by the dynamical phenomena at the surface. Now these variations must react on the development of eruptions and spots If the currents are weak—viz. if the transfer of heat from the interior to the surface is comparatively small—the cooling of the atmosphere must proceed rapidly, and hence the development of eruptions, which are a direct consequence of this process of cooling, must be energetic. At such times we have, therefore, to expect solar cycles with a powerful display of dynamical phenomena. If, on the other hand, the currents are intense—viz. if the heat-supply from the interior is vigorous—the rate of atmospheric cooling will be small, and we have then to expect cycles with only a weak development of surface phenomena.

Since the quantity a depends on the rate of cooling of the atmospheric layers, it will attain high values at times when the spot-development is powerful, and *vice versâ*. Now the greater a, the greater will be the difference between λ_1^2 and λ_2^2, and, consequently, the earlier must the time of maximum, t_m, occur. Hence the position of the maximum in the spot period relatively to the preceding minimum must depend on the greater or less vigour of spot-development during the cycle, inasmuch as the time of maximum must be the more in advance of the centre of the period the greater the display of the dynamical phenomena. This important conclusion, arrived at by purely theoretical considerations, is amply corroborated by the facts. I refer in this respect to a recent publication of Dr. W. Lockyer, in which this peculiar shift of the maximum is pointed out as a feature of the observed spot-curves.

Fig 2. Deviations of the Mean Annual Temperature from the Normal.



The object of this brief abstract being merely an exposition of the main principles upon which I have ventured to build a new solar theory, I shall not enter upon its various applications to the phenomena connected with the periodic changes in the display of forces at the sun's surface. In this respect the theory will be submitted to an exhaustive test in my paper in the *Annals*. In one important point it involves a radical deviation from the views hitherto held. So far investigators have almost unanimously adhered to the traditional view that an increase in the dynamical forces at the sun's surface indicates at the same time an augmentation of his light- and heat-radiation into the universe. A theory founded on this assumption would have to account, not only for the extra expenditure of force into space, but also for the simultaneous increased development of force in the sun. But in the theory here proposed the exactly opposite conclusion is arrived at. Here the forces which we see acting on the sun are called into existence by the accumulation of such parts of his radiating energy as have been *prevented* from being thrown off into the universe. Thus a *surplus* of energy working on the sun means a *deficit* of energy communicated to space.

It will be important, then, to ascertain how far this conclusion can be verified by observed facts. Modern researches seem, indeed, to corroborate this theoretical result. If the theory be true, the temperature of the solar layers inside the absorbing atmosphere should be higher at the maxima than at the minima of solar activity, while the temperature of a body in space, which receives its heat from the sun, should vary inversely. In proof of the first conclusion I may refer to Sir Norman Lockyer's results with regard to the behaviour of the lines widened in the spectra of sunspots, from which he infers that the matter composing the spots must be of higher temperature at the times of maxima. The second conclusion, on the other hand, is corroborated by all the more important researches which have recently been made regarding a connection between the changes of terrestrial temperature and solar activity. Of some of these I subjoin the main results in Fig. 2, which exhibits the observed changes in the mean annual temperature at tropical and subtropical stations and the corresponding variations of solar activity. It will be seen that for the whole period from 1821 until 1898 the temperature-curve follows most accurately the fluctuations of the *inverted* spot-curve, thus so far proving the validity of the second conclusion, that space receives *less* heat at the maxima than at the minima of solar activity.

J. HALM.

MICROSCOPICAL EXAMINATION OF ALLOYS OF COPPER AND TIN.[1]

THE microstructure of the copper-tin alloys has been studied by Behrens, Charpy, Stead and others. Recently Messrs. Heycock and Neville (*Phil. Trans.* Royal Society, 1901; Glasgow meeting, British Association) have published several papers on the effect of quenching upon the microstructure.

Behrens divides the bronzes into two principal groups—those rich in copper, containing from 1 to 25 per cent. of tin, and those rich in tin, containing more than 25 per cent. of tin. With the exception of the metals for mirrors (25 to 35 per cent. of tin), which appear homogeneous, Mr. Behrens says that in all bronzes a portion rich in copper or rich in tin may be detected, forming the fundamental mass, the former in alloys rich in copper, the latter in those rich in tin.

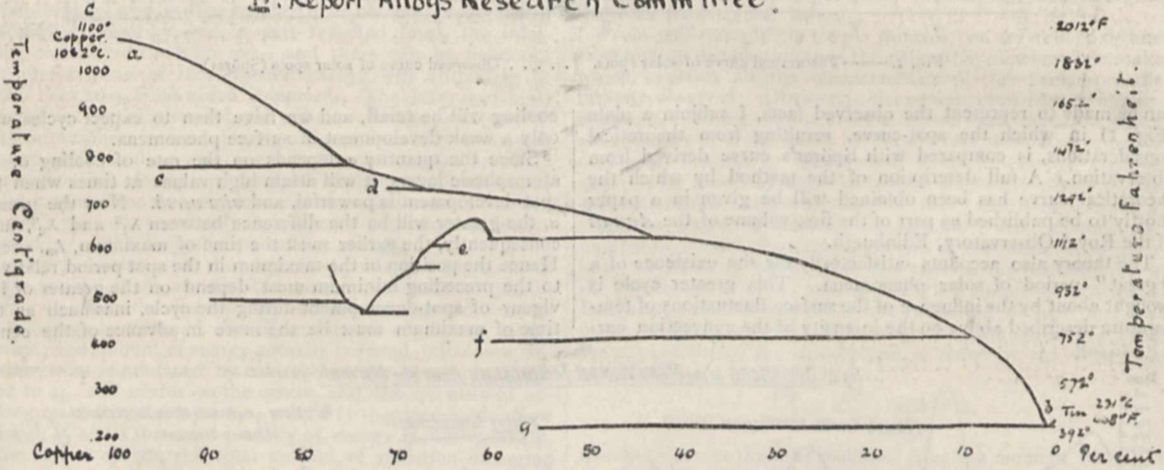
Charpy (*Metallographist*, vol. i. p. 193) divides them into those rich in copper, containing 100 to 73 per cent. of copper, and those rich in tin, which are again divided into four groups—0 to 3 per cent. of copper, in which tin crystallises in the matrix; 3 to 55 per cent. of copper, in which a compound of tin and copper crystallises out of the matrix; 55 to 65 per cent. of copper, which have a structure quite homogeneous and difficult to resolve; and 65 to 73 per cent. of copper, in which hard white grains crystallise in the higher eutectic.

The curve of fusibility, as determined by Le Chatelier, is composed of three branches, forming by their intersections two points corresponding to alloys with 3 and 72 per cent. of copper.

0 to 3 per cent. of copper:			straight: fall.
3 to 72	,,	,,	uniformly curved: rise.
72 to 100	,,	,,	almost straight: rise.

This curve and the results of Charpy (*Bull.* Soc. d'Encouragement, March, 1897) from microscopic analysis closely agree.

Fig 1. Freezing-point Curve of Copper-Tin Alloys.
Vth. Report Alloys Research Committee.



If, however, we study the complete cooling curve of the copper-tin alloys, by Sir William Roberts-Austen (Fig. 1), the meaning of only a part of the curve will be found to have been explained by previous workers. The branches *c*, *d*, *e* and *f* remain unaccounted for.

The result of the microscopical study of these alloys is shortly as follows:—

0 *to* 1 *per cent. Copper.*—On the addition of even 0·1 per cent. of copper to tin, a new constituent surrounding the grains of tin can be seen. As the percentage of copper increases, the amount of enveloping material increases also, and the tin grains decrease in size and number until about 1 per cent. copper; they entirely disappear when the whole mass is composed of the first eutectic alloy. When these alloys are cast, the grains of tin are greatly reduced in size.

1 *to* 8 *per cent. Copper.*—When the copper is increased above 1 per cent., thin bright needles are seen, which increase in size and number and vary in their method of grouping until 8 per cent. of copper is reached. Their composition varies also, increasing from 33·5 per cent. Cu to 44 per cent. Cu, as was pointed out by Stead (*Journal* of the Society of Chemical Industry, June, 1897). Casting produces a network of fine crystallites, which tend to set along definite directions forming skeleton crystals. Cooling in the furnace greatly increases the size of the bright crystals and diminishes their number proportionately.

9 to 40 *per cent. Copper.*—With 9 per cent. Cu a new constituent crystallises out in forms similar in section to the crystals

[1] Abstract of a paper by Mr. William Campbell, Columbia University, New York, late of the Royal School of Mines, London. Read before the Institution of Mechanical Engineers on December 20, 1901.

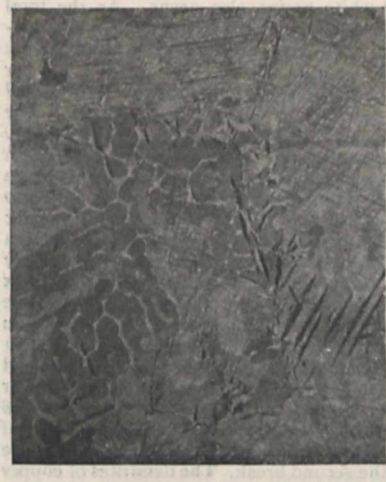


FIG. 2.—Cu 66 per cent. × 33. V.

FIG. 3.—Cu 66 per cent. × 33. V.

FIG. 4.—Cu 66 per cent. × 33. V.

FIG. 5.—Cu 66 per cent. × 33. V.

FIG. 6.—Cu 80 per cent., furnace-cooled, × 33. V.

FIG. 7.—Surface of Fig. 6.

FIG. 8.—Cu 80 per cent. × 33. V.

FIG. 9.—Cu 80 per cent. × 33. V.

FIG. 10.—Cu 80 per cent., cast, × 33. V.

V, vertical illumination.

in the 1 to 8 per cent. alloys, but differing from them in never occurring hollow. On oxidation it becomes very dark and is easily distinguished from the other two constituents of the alloy. In form it is plate-like, and around it crystallises out the bright constituent characteristic of the 1 to 8 per cent. alloys, either as a rough envelope of fairly uniform thickness or as projecting crystals. Stead was the first to draw attention to the fact that the crystals of this division of the series were composite. As the copper approaches 40 per cent., the plate-like crystals are grouped together in parallel bunches. Casting masks the composite character of the crystals, if, in the lower percentages, it does not destroy it; for under 20 per cent. Cu, the crystals cannot be resolved into two components under high powers.

41 *to* 61·7 *per cent. Copper.*—At 41 per cent. Cu the crystals are small, lath-shaped, and arranged more or less in groups. The alloy is brittle, and this brittleness increases with the percentage of copper. With each addition of copper, the groups of composite crystals become more and more compact and the amount of eutectic diminishes until at 56 per cent. Cu it disappears (Stead, *Journal* of the Society of Chemical Industry, June, 1897), and the bright constituent of the crystals forms the groundmass. When 61·7 per cent. Cu is reached, the bright constituent disappears and we have a homogeneous mass of $SnCu_3$, probably a definite compound. Casting tends to harden and toughen these alloys. Seeing that these alloys up to about 56 per cent. Cu show four breaks in their cooling curves, one would naturally expect to find four different constituents in each. Only three, however, can be distinguished. Quenching below the first and second breaks gives a difference in structure only. As in the alloys containing 61·7 per cent. Cu and onwards, branch *e* of the curve (Fig. 1) corresponds to a rearrangement in the solid, and as the difference between the 40 and 41 per cent. Cu alloys is one of structure only, we may assume that the second retardation in the cooling curve (*e*) is one of rearrangement also.

61·7 *to* 68·28 *per cent. Copper*, $SnCu_3$ *to* $SnCu_4$.—The changes which take place between these two points can only be observed when the alloys are very slowly cooled. The alloys set as a whole at the first break and tend to rearrange themselves subsequently in the solid, on branch *e* (Fig. 1). Each addition of copper to $SnCu_3$ brings in more and more of a bright constituent, probably $SnCu_4$. Quenching and casting produces structures entirely new. Figs. 2–5 show the 66 per cent. Cu alloy differently cooled. Fig. 2 was quenched on the first break. There is a cell-like structure with light-coloured walls or boundaries. In places the change has gone further, and we get the fine cross-hatching characteristic of Fig. 3, which has been quenched below the first break. The cell-like structure has entirely disappeared. Fig. 4 has been quenched below the second break and resembles a slowly-cooled alloy, except that in the latter there are distinct traces of a eutectic structure. Fig. 5 has been cast on an iron plate, and the "schiller" structure is well developed. At 68·2 per cent. Cu the alloy is homogeneous, has a conchoidal fracture and is extremely brittle.

68·28 *to* 75 *per cent. Copper.*—Immediately the copper is increased above 68·3 per cent., the second eutectic makes its appearance. As the copper increases, the grains of $SnCu_4$ split up into bright veins and dendrites, surrounded by the eutectic. The veins and dendrites decrease and disappear at 75 per cent. Cu, where the mass is made up entirely of the eutectic. The alloys are best studied when furnace-cooled; their surfaces above 71 per cent. Cu are seen to consist of a network of dendrites or skeleton crystals resembling those seen on the surface of a pure metal. This surface structure continues right up to the copper end of the series. It was soon noticed that the internal structure of the alloys from 70 to 75 per cent. Cu showed no trace of these dendrites, and so the surfaces of several were rubbed down and polished. In each case their structure was the same as that of the centre of the alloy, which shows that these dendrites have split up and rearranged themselves after solidification, and all that remains of them is this surface structure. Casting makes the structure very minute, and about 73 per cent. Cu traces of the skeleton crystals can be seen in the centre of the ingot. They appear dark and structureless, as if they had been unable to resolve themselves into their two constituents.

75 *to* 100 *per cent. Copper.*—When 76 per cent. copper is present, two new constituents make their appearance and the alloy assumes a yellow tint. In section we find yellow grains, surrounded by a bright white border, set in the second eutectic, in which small bright white grains also occur. As the total copper is increased, the yellow grains increase, forming dendrites and skeleton crystals, the white borders and grains merge together and the eutectic decreases till at about 90 per cent. it disappears. The yellow grains become darker and darker (contain less and less tin in solid solution). The light borders diminish and disappear, about 95 per cent. leaving copper dendrites behind. These dendrites vary in composition from centre to outside, and so the centre etches a darker colour. They darken with increase of copper until 100 per cent. is reached. Casting tends to make the copper grains solidify, containing a considerable quantity of tin. In this way the eutectic can be made to disappear considerably below 90 per cent Cu. Quenching shows that the upper break corresponds to the solidification of the copper; break 2 to the solidification of the groundmass which splits up into a eutectic when branch *e* is reached. Fig. 6 contains 80 per cent. Cu furnace-cooled, whilst Fig. 7 shows the surface of the same and also that with this percentage of copper the dendrites of copper have directed the formation of the surface skeletons. Fig. 8 is the same alloy quenched below first break. The dendrites of copper are seen set in a structureless matrix. Fig. 9 is the same alloy quenched below the second break. The dendrites of copper (light, because of a different etching process) are seen, set in a fibrous matrix—the eutectic of which the formation has been faced. Fig. 10 shows the same alloy cast. As its appearance would indicate, the alloy is very tough and cuts well.

It seems clear then that branch *e* of the cooling curve is one of change in the solid, and this conclusion has been proved beyond doubt by the beautiful work of Heycock and Neville published by the Royal Society. When one considers the many and distinct different structures in the series produced by quenching at different temperatures and by reheating and then quenching, it is quite evident that the changes which take place during the cooling of an alloy of copper and tin, especially in the neighbourhood of the second eutectic, are even more numerous than those of the carbon-irons.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Allen studentship, value 250*l.* for one year, for research in connection with medicine, mathematics, physics and chemistry, biology and geology, or moral science, will be filled up at the end of the present term. It is open to graduates under the age of twenty-eight on January 8.

Principal E. H. Griffiths, F.R.S., of Cardiff University College, has been approved for the degree of Doctor of Science.

The Rede lecture will be delivered next term by Prof. Osborne Reynolds, F.R.S., of Owens College, Manchester.

Mr. W. N. Shaw, F.R.S., will give three lectures, on February 13, 20 and 27, on the physics of the ventilation of buildings.

Prof. Tilden, F.R.S., has been appointed an elector to the chair of chemistry; Lord Rayleigh, F.R.S., an elector to the chairs of chemistry and of mechanism; Dr. Hill, to the anatomy chair; Mr. F. Darwin, F.R.S., to the botany chair; Dr. Hinde, F.R.S., to the geology chair (Woodwardian); Sir G. G. Stokes, F.R.S., to the Jacksonian and Cavendish chairs; Dr. D. MacAlister, to the Downing chair of medicine; Dr. Hugo Müller, F.R.S., to the chair of mineralogy; Prof. E. Ray Lankester, F.R.S., to the chair of zoology and comparative anatomy; Prof. McKendrick, F.R.S., to the chair of physiology; Lord Lister, F.R.S., to the chair of pathology; and Prof. Marshall Ward, F.R.S., to the chair of agriculture.

Dr. J. Reynolds Green, F.R.S., has been elected to a fellowship at Downing College.

THE University College, Bristol, does not receive the generous support given to similar colleges elsewhere, but the report of the council for the session 1900-01 shows that much valuable work has been done in spite of limited means and opportunities. Important papers have been published by various members of the scientific staff and others are in progress. The clinical and bacteriological research laboratory, which has been at work under Prof. Stanley Kent for little more than a year, has, among other matters, been able to afford valuable aid to the Medical Officer of Health in reporting upon the presence of plague infection in material submitted for examination. In one case, plague infection was found to be undoubtedly present, and the report of the laboratory upon it was made immediately. In a second case the appearances presented were suspicious, and the report of the laboratory enabled precautions to be taken to safeguard the city in the event of true plague appearing. More accommodation for this kind of research work is required, as there is no lack of persons willing to undertake it. The same remark applies to other departments of the College. If people of means in Bristol and the neighbourhood took any interest in educational progress, the establishment of the University of Birmingham, and the movement in favour of other universities of a similar kind, would inspire them to action in the same direction. There is room for a University of the West of England, and if Bristol does not rise to its opportunity another city of the west will take its place. The subject has been brought up over and over again, and only a few days ago Mr. Haldane spoke in favour of it at the annual dinner of the University College Colston Society. The Bishop of Hereford also alludes to it at the end of the present report. But the rich citizens of Bristol do not seem to understand what has been done by private persons for higher education in cities like Liverpool, Birmingham and Manchester, or if they know they apparently have no desire to follow the example. There will have to be a complete awakening of the spirit of pride in local resources for education and research before Bristol can make any real movement towards a University of the West of England.

SCIENTIFIC SERIALS.

Transactions of the American Mathematical Society, vol. iii. No. 1, January.—On a class of automorphic functions, by J. L. Hutchinson. In Burkhardt's "Ueber die darstellung einiger fälle der automorphen primformen durch Specielle Thetareihen," the following monodromy group of the Riemann surface, $y^3 = (x-a_1)(x-a_2)(x-\beta_1)^2(x-\beta_2)^2$, is considered, and he shows how a certain prime form which is automorphic for the group can be expressed by a theta series. Further results are here given concerning the group and the functions belonging to it, the chief object being to obtain explicit analytic formulæ by means of which all functions of the group can be represented. To this end the theta-fuchsian functions of Poincaré are introduced, and their expressions in terms of the hyperelliptic theta series deduced.—Concerning the existence of surfaces capable of conformal representation upon the plane in such a manner that geodetic lines are represented by a prescribed system of curves, by H. F. Stecker, is in continuation of a previous paper under nearly the same title (vol. ii. p. 152).—Zur erklärung der Bogenlänge und der inhaltes einer Krummen fläche, by O. Stoll (*cf.* the author's "Grundzüge der Differential- und Integralrechnung," Bd. 2, and *Math. Ann.*, Bd. 18).—The groups of Steiner in problems of contact, by Dr. L. E. Dickson, gives an elementary proof of Jordan's ("Traité," pp. 229–249). Reference is given to Steiner and Hesse (*Journal für Math.*, vol. xlix. (1855) and vol. lxiii. (1864), and to papers by the author (*Bulletin* Amer. Math. Soc., vol. iv., and the *American Journal of Mathematics*, vol. xxiii. pp. 337–377).—Quaternion space, by A. S. Hathaway, follows up Stringham's work in vol. ii. p. 183, but frequent reference is made to Clifford's paper on biquaternions. Stringham deals analytically with the equations of loci and develops the geometry by the interpretation of those equations; the author uses a more synthetic method, which interprets the quaternion symbols themselves instead of the equations between them. It is this divergence which constitutes the general difference between the methods of Cayley and Tait. Clifford stated the synthetic view in his Further note on biquaternions.—Reciprocal systems of linear differential equations, by E. J. Wilczynski, arrives at interesting results in connection with previous papers (*Transactions*, vol. ii. No. 4; *American Journal of Mathematics*, vol. xxiii.).—On the invariants of quadratic differential forms, by C. N. Haskins, investigates, by means of Lie's theory of continuous groups, the problem of determining the number of invariants of the general quadratic form in n variables. Numerous references occur in the paper.—On the nature and use of the functions employed in the recognition of quadratic residues, by Dr. E. McClintock, refers to Tannery, "Leçons d'Arithmétique," Bachmann, "Elemente der Zahlentheorie," and to Baumgart, "Ueber der Quadratische Reciprocitätsgezetz."—A determination of the number of real and imaginary roots of the hypergeometric series, by E. B. Van Vleck. Concisely we must refer to Klein (*Math. Ann.*, vol. xxxvii. p. 573) for the number of the roots of the equation considered between 0 and $-\infty$. Mr. Van Vleck claims that he gives, for the first time, the number of imaginary roots. Numerous references and diagrams (six and a page of sixteen) accompany the text.—The second variation of a definite integral when one end-point is variable, by G. A. Bliss. The method which the author applies to the discussion of the case in which one end-point moves on a fixed curve is closely analogous to that of Weierstrass ("Lectures on the Calculus of Variations," 1879). In the present case terms outside of the integral sign are taken into consideration. Then, as a result of the discussion, the analogue of Jacobi's criterion is derived, defining, apparently in a new way, the critical point (Kneser's "Brennpunkt") for the fixed curve along which the end-point varies. Then the relation between the critical and conjugate points is discussed.—On the projective axioms of geometry, by E. H. Moore, contains a consideration of the axioms called by Hilbert ("Grundlagen der Geometrie") the axioms of connection and of order, and by Schur ("Über die Grundlagen der Geometrie") the projective axioms of geometry. There are several citations of authorities, such as Peano, Pasch and Ingrami.

Bulletin of the American Mathematical Society, January.—Note on Mr. George Peirce's approximate construction for π, by E. Lemoine. This article gives four constructions suggested by a discussion of Mr. Peirce's which we have previously noticed (*Bulletin*, July, 1901). The relative theoretic exactness is determined by calculating the true value of the length which in each case approximately represents π. The solutions are worked out by aid of the geometrographic notation. A slight sketch of this method, sufficient for the present purpose, is given. (For a fuller account, reference may be made to M. Lemoine's "La Géométrografie" or to the "Traité de Géométrie" in the *Archiv. der Mathematik und Physik*, April and May, 1901, vol. i., Gauthier-Villars). There is also appended a close approximation to the trisection of an angle by C. Störmer worked by the same method. There are several diagrams.—Concerning the elliptic $\wp\,(g_2 g_3 z)$ functions as coordinates in a line complex, and certain related theorems, by Dr. H. F. Stecker, is an application of the coordinates to the Kummer surface and certain other configurations (*cf.* Klein, *Math. Ann.* vol. v., pp. 294–5).—A short note on the Abelian groups which are conformal with non-Abelian groups follows, by Dr. G. A. Miller. Dr. S. E. Slocum writes on the infinitesimal generators of certain parameter groups. The paper opens with a *résumé* of the method employed by the author on pp. 97–103 of the *Proceedings* of the American Academy of Arts and Sciences, vol. xxxvi., and then proceeds to give tables in which are enumerated all possible types of structure of two-, three- and four-parameter complex groups as given by Lie, and under each structure are given the symbols of the infinitesimal transformations which generate the parameter group corresponding to that structure, obtained by the method referred to above (*cf.* Lie, "Continuierliche Gruppen," pp. 565–589; "Transformations Gruppen," vol. iii., pp. 713–730).—Notices follow of the "Einführung in die Theorie der Differential gleichungen mit einer unabhängigen Variabeln" of Dr. L. Schlesinger and of Prof. Hatzidakis's "ἐισαγωγὴ εἰς τὴν 'Ανωτέραν 'Αλγέβραν."—The usual information of interest to mathematicians follows in the form of notes and new publications.

Annals of Mathematics, January.—Some applications of the method of abridged notation, by Maxime Bôcher, is an interesting elementary paper the nature of which may be gathered from an illustration. Let the sides of a triangle be $u=0$, $v=0$, $w=0$ (where $u \equiv x\cos a + y\sin a - p$), then $u-v=0$, $v-w=0$, $w-u=0$ are the bisectors of the angles, and as the sum of the sinisters vanishes identically we get the property of the bisectors of the angles cointersecting in a point. If, again, $u \equiv x^2+y^2+ax+by+c=0$ and so on, we can show that the common chords of three circles meet in a point. The author then proceeds to the proof of Desargues' theorem and thence to generalisations for four circles and for curves of the nth order, and extends, by suggestion, his results to surfaces.—On the roots of functions connected by a linear recurrent relation of the second order, by M. B. Porter, reproduces in part some unpublished theorems of Sturm (*cf.* "Liouville," vol. i.), and shows how, by means of the Cauchy-Lipschitz theorem for the existence of solutions of a differential equation, it is possible to establish rigorously the analogous theorems, so far as they exist, for the homogeneous linear differential equations of the second order. The article closes with some applications.—Space of constant curvature, by F. S. Woods, is an attempt to present Riemann's ideas (*cf.* the "Ueber die Hypothesen, welche der Geometrie zu Grunde liegen") in an elementary form. The paper is given in part and is useful, in addition to the results worked out, for its bibliographical references.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, January 23.—"The Affinity of Tmesipteris with the Sphenophyllales." By A. P. W. Thomas, M.A., F.L.S., University College, Auckland, New Zealand.

In the present paper the author deals with the nature of the synangium of Tmesipteris, as based on the study of variations observed in the sporophyll, beyond the limits already recorded by Bower.

The term "sporophyll" is used to denote the whole fertile structure, the term "synangium" restricted to the sporangiophore. Three types of variation are recorded, viz. (1) that of repeated dichotomy of the sporophyll with two to three synangia; (2) that in which the synangium is raised upon a pedicel or stalk; (3) that in which the synangium is replaced by a leaf-lobe of normal appearance. It is shown that abnormality in the sporophylls and synangia, which commonly occurs at the beginnings or ends of the fertile zones, is not found in cases where the sporophyll shows excessive leaf development. In these it occurs rather towards the middle region, and it is inferred that if the nutritive conditions remained equally satisfactory throughout, the whole sporophyll series should show repeated dichotomy.

Concerning the second type of variation, the synangium is found to have become so revolved upon a transverse axis that its longitudinal groove faces outwards between the leaf-lobes, assuming a position the more favourable to dispersal of the spores. In the third type the leaf is shown to be forked, although the synangium, if present at all, exists only in an abortive form. From the fuller study of this, the author suggests that the synangium is the morphological equivalent of a ventral leaf-lobe.

Passing to questions of classification, the author refers to the difficulties in reconciling the sporangium-bearing structures of the Psilotæ with those of the typical Lycopodinæ. He enters into a comparison with the extinct Sphenophyllales, with especial reference to Bowmanites and Cheirostrobus, and concludes that the relationships of Tmesipteris and Psilotum with this group are perhaps even closer than is supposed by Scott.

In an addendum, received since this paper was announced, the author makes good his desire to deal extensively with the Psilotum sporophyll, the leaves of which, though greatly reduced and xerophytic, are shown to be essentially similar to those of Tmesipteris.

Society for Psychical Research, January 31.—Dr. Oliver Lodge, F.R.S., delivered his presidential address. Dealing first with the phenomena of trance, lucidity and clairvoyance, he expressed the opinion that much more information was required before we could even formulate the problems raised by these faculties. With regard to physical phenomena, he thought much of the extra difficulty of accepting evidence for unusual phenomena was due to the *a priori* notion that such occurrences are contrary to natural law. We cannot, however, clearly tell that they are contrary to natural law; they are only contrary to and supplementary to our usual experience. The objection of science to psychical research is mainly due to the fact that it regards psychical phenomena as unintelligible. It is accustomed to simplify its problems by the method of abstraction and has got into the habit of thinking that it actually excludes disturbing causes; the abstraction cannot really exclude from the universe anything apparently disorderly. Theoretically, this is universally admitted; practically science has excluded psychical phenomena from its experimental area. He was not prepared to say that physical phenomena such as materialisations, the passage of matter through matter, and levitation were impossible and absurd, so that no testimony ought to produce any effect on our incredulity. Extreme caution was necessary and full control must be allowed to the observers. His personal belief was that man survived death, and this belief had been produced by scientific evidence. He did not attribute the physical phenomena of spiritualism to the agency of the departed, but was disposed to regard trance utterances as in some cases due to telepathic communication with some unconscious stratum of a departed person.

Royal Microscopical Society, January 15.—Mr. Wm. Carruthers, F.R.S., president, in the chair.—This being the annual meeting of the Society, the president gave an address on the scientific work of Nehemiah Grew, from 1641–1712, whom he defended from the charges of plagiarism which had been brought against him in respect to his discoveries as to plant structure.—Mr. E. A. Parsons gave an exhibition of malaria parasites under a number of microscopes, lent for the occasion by Messrs. Chas. Baker.—Messrs. Ross exhibited their new form of standard microscope, designed specially for the use of medical students, fitted with a new form of fine adjustment. Messrs. Ross also exhibited a simple lens for dark ground illumination. It consists of a meniscus lens bored through its centre to receive a spot made of vulcanite provided with a stem to drop into the hole in the centre of the lens.

Geological Society, January 22.—Mr. J. J. H. Teall, V.P.R.S., president, in the chair.—The fossiliferous Silurian beds and associated igneous rocks of the Clogher Head district (county Kerry), by Prof. S. H. Reynolds and Mr. C. I. Gardiner. The authors give a detailed description of the coast from Dunquin past Clogher Head to Coosglass (south of Sybil Point), and of the western side of Smerwick Harbour. They next deal with the inland exposures, which are not very frequent, but include considerable rock-masses at Croaghmarhin and Minaunmore Rock. The rocks consist of sandstones, slates, calcareous flags, ashes and ashy conglomerates, rhyolitic lava-flows and various intrusive rocks. The general structure is an S-shaped fold, inverted towards the north so that the dip of the beds is approximately south-easterly, and the oldest beds occur to the north, at Coosglass. Both anticline and syncline are faulted, and a patch of Old Red Sandstone is caught in under the synclinal thrust at Coosmore. Fossils, mainly corals, brachiopods, lamellibranchs and gasteropods are fairly abundant; but trilobites are rare and graptolites absent. The whole of the fossiliferous rocks are of Silurian age; the majority of those exposed on the coast are of Wenlock or Wenlock-Llandovery age, while the majority of those exposed inland are of Ludlow age.—A process for the mineral analysis of rocks, by Prof. W. J. Sollas, F.R.S. The method proposed is to obtain a quantitative estimation of the mineral composition of a rock, and from the known composition of the minerals to calculate the percentage-composition of the rock. The specific gravities of the minerals are first determined by means of a diffusion-column of methylene-iodide and beads of known specific gravity, and the presence or absence of particular minerals settled for a certainty. Next, the separation of the minerals in a weighed quantity of the powdered rock is undertaken by means of a special separator, the method being illustrated by the example of a rock containing orthoclase (sp. gr. 2·56), quartz (2·65), andesine (2·67), biotite (3·1), pyroxene (3·3) and magnetite. The first separation would be with a liquid of sp. gr. 2·885, the mean of that of andesine and biotite; the next with a liquid of sp. gr. 2·66; the next 2·605, and so on for the other constituents. The separated minerals are dried and weighed, the loss distributed, and the analysis checked by comparing the specific gravity of the rock in bulk with that calculated from the specific gravity and proportion by weight of its constituents.

DUBLIN.

Royal Irish Academy, January 13.—Prof. R. Atkinson, president, in the chair.—Prof. T. Johnson communicated, on behalf of the fauna and flora committee of the Royal Irish Academy, a paper by Mr. W. West and Prof. G. S. West entitled "A Contribution to the Freshwater Algæ of the North of Ireland." This paper gives the results of the examination of material collected by the authors in 1900 and 1901 in Lough Neagh and district, and in co. Donegal. 139 genera, 604 species and 106 varieties are recorded. Of these some twelve, described and illustrated, have been hitherto unknown, twenty-four others are new to the British Isles, many others new to Ireland, and the distribution of yet others, recorded by the late Mr. W. Archer, F.R.S., and Rev. E. O'Meara, is largely extended. The paper is illustrated by some ninety figures. Three desmids, *Micrasterias furcata*, Ag., *Staurastrum Arctiscon* (Ehrenb.), Lund., and *Staurastrum longispinum* (Bail.), Arch., are of particular interest in that they appear to be confined to the western shores of the British Isles—being known only as occurring in the small lakes in the hilly districts of Connemara and Donegal in Ireland, the lakes of the Snowdon range in North Wales, and from similar situations in the extreme north-west of Scotland. No species of Vaucheria were found, and *Botrydium granulatum* is recorded for the first time in Ireland.

Royal Dublin Society, December 18, 1901.—Dr. W. E. Adeney in the chair.—Sir Howard Grubb, F.R.S., on some new forms of geodetical instruments. The author applies the principle he recently described (*Scientific Transactions*, Royal Dublin Society, vol. vii. p. 321) for gun sights for large and small ordance to various forms of geodetical instruments.—Prof. J. Joly, F.R.S., on sedimentation experiments and theories. T he rates of settlement of suspensions consisting of 5 grammes of finely powdered solid in 12 c.c. of water containing ions in various degrees of concentration, indicate that above a certain concentration the rate of fall of the surface of the suspension is fairly independent of the degree of concentration. Below certain concentrations (about five times greater for monad positive ions than for diad) a distinct surface to the descending suspension fails, and the sediment is only seen to collect from the bottom of the vessel upwards. A suspension precipitated at a concentration so low as to be near the point of failure to show surface will, if re-shaken, not again precipitate with a distinct surface. On removing the electrolyte from such an "exhausted" suspension after it has stood sufficiently long to settle, it is found that the liquid is as effective as at first in producing surface if a fresh sample of the powder is used. On the other hand, the original powder will not again show surface when treated with fresh electrolyte of the same strength, but it will require a much more concentrated electrolyte to do so. The failure is therefore to be traced to some alteration in the solid particles. On testing the fresh powder it is found that this is negative towards distilled water; the used powder is apparently quite neutral towards its salt solution. An explanation of sedimentation is advanced, based on the low specific inductive capacity of the solid particle compared with the specific inductive capacity of the water, the charges on the ions being assumed to exert an expulsive action consequent on the increased energy required to establish the electric field in the medium of low specific inductive capacity. In other words, the solid particles have a de-ionising influence, and experience a reaction in consequence, which will tend to retain in juxtaposition particles which from any cause are once approximated. A principal cause of aggregation upon first precipitation is to be ascribed to the negative sign of the particles leading to motions, all in the end favourable to aggregation, seeing that the state of aggregation is alone stable in the medium. On second disturbance the particles are neutral, and aggregates are not formed with sufficient rapidity to lead to a general and simultaneous descent of the suspension.—Lord Rosse, K.P., F.R.S., exhibited working models of apparatus for turning aside leaves in the water supply of a turbine.—Sir Howard Grubb exhibited the cœlostat constructed for the Royal Dublin Society and used at the solar eclipse of 1900.

January 22.—Prof. W. F. Barrett, F.R.S., in the chair.—Mr. W. E. Wilson, F.R.S., on the nebulæ surrounding Nova Persei.—Prof. Barrett, Mr. W. Brown and Mr. R. A. Hadfield, on researches on the electric properties of an extensive series of alloys of iron.—Mr. Richard J. Moss, on an improved volumetric method for the determination of sugar. In Pavy's modification of Fehling's method, cupric oxide is reduced in presence of a a large excess of ammonia, which prevents the precipitation of cuprous oxide. The temperature of the boiling liquid varies from about 70° C. to 90° C., and the rate of reduction varies to a corresponding extent. The author overcomes this objection to the method by using a much smaller quantity of ammonia, and conducting the titration under pressure, at the temperature of boiling water. The reduction of the cupric oxide is apparently instantaneous, and the results are very sharp and constant.

PARIS.

Academy of Sciences, February 3.—M. Bouquet de la Grye in the chair.—On a new synthesis of formic acid, by M. Henri Moissan. Potassium hydride absorbs carbonic acid at the ordinary temperatures producing potassium formate. The formation of formic acid was confirmed by the production of the free acid, which showed the ordinary reducing properties, and by the preparation and analysis of the crystallised lead salt. Carbon monoxide also reacts with potassium hydride at 150° C., potassium formate being formed and carbon set free.—On certain cases of adherence of a viscous liquid to the solid with which it is in contact, by M. P. Duhem.—New observations on the folds of the phosphatic chalk in the Somme, by M. J. Gosselet. The strongly inclined layers of phosphatic chalk discovered at Étaves in 1896 might have been looked upon as a local accident, but the same facts have now been noticed at Hargicourt, and at two places at a much greater distance, Éclusier, between Peronne and Albert, and at Crécy in Ponthieu. These layers are small, but are too widely extended to be the result of a purely local accident. The facts observed confirm the views of M. Marcel Bertrand on the slow and progressive formation of the folds of a geological basin.—Remarks by M. Albert Gaudry on presenting to the Academy a work on the comparison of the teeth of man and the anthropomorphic apes.—M. Alfred Picard was elected a free member in the place of the late M. de Jonquières.—Observations of the sun made at the Observatory of Lyons with the Brunner 16 cm. equatorial during the second quarter of 1901, by M. J. Guillaume. Tables are given showing the number of spots, their distribution in latitude and the distribution of the faculæ in latitude.—Researches on the Hertzian waves emanating from the sun, by M. Charles Nordmann. The experiments described were carried out at the Grand-Mulets on Mt. Blanc, the weather conditions being too unfavourable to utilise the observatory at the summit. The conclusions drawn from the experiments are that the sun does not emit electric radiations capable of affecting radioconductors, or that, if they are given off, they are completely absorbed by its atmosphere or by the upper portions of the terrestrial atmosphere.—Some remarks on entire functions, by M. Edmond Maillet.—The variation of the electromotive force and the temperature coefficient of the Daniell cell with the concentration of the zinc sulphate solution, by M. J. Chaudier. Starting with a saturated solution, the electromotive force of a Daniell cell increases when the concentration of the zinc sulphate diminishes, passes through a maximum for a $\frac{1}{2}$ per cent. solution, and then again decreases for smaller concentrations. The temperature coefficient, which at first is negative, increases and becomes zero at a concentration of between 7 and 8 per cent.; but, after having attained a positive maximum, it falls off and vanishes a second time for a $\frac{1}{2}$ per cent. solution. From this it follows that the Daniell cell furnishes a standard of electromotive force which is independent of the temperature when it is made up with a saturated solution of copper sulphate and a 7·5 per cent. or $\frac{1}{2}$ per cent. solution of zinc sulphate.—On the galvanometric observation of distant storms, by M. J. J. Landerer. With the arrangement described the electrical disturbances due to distant storms have been observed up to a distance of 240 kilometres.—Comparison between the properties of hydrogen selenide and those of hydrogen sulphide, by MM. de Forcrand and Fonzes-Diacon. Data for hydrogen sulphide are given in the present paper. The boiling-point at a pressure of 773 mm. was found to be −61° C., and the melting-point −86° C. The density of liquid sulphuretted hydrogen at its boiling-point is 0·86. A comparison with the data previously given for hydrogen selenide shows great analogies between the two compounds. They have practically identical molecular volumes, their boiling-points expressed as fractions of their critical temperatures are the same, and the ratio of latent heat of vaporisation to the boiling-point is also nearly the same for the two gases.—On the action of lithium-ammonium on antimony, and on the properties of the antimonide of lithium, by M. P. Lebeau. Lithium-ammonium reacts upon antimony, giving a compound of the formula $SbLi_3$, identical with that previously obtained by electrolysis. This substance dissolves in liquid ammonia, uniting with it to form the compound $SbLi_3NH_3$. Lithium antimonide is less fusible than either of its constituents, and possesses very energetic reducing properties.—On oxy-isopropyl-hypophosphorous acid, by M. C. Marie.—On the hydrolysis of pyromucic urethane, by M. R. Marquis.—The action of nitric acid upon trichloro- and tribromo-veratrol, by M. H. Cousin. The action of nitric acid upon these substituted veratrols gives rise to mono-nitro-derivatives, the reaction being altogether different from the action of nitric acid upon the tetra-chloro- and tetrabromo-veratrols.—On some derivatives of glutamine, by M. E. Roux. A description of the mode of preparation and properties of various derivatives of glucamine.—The action of aluminium chloride on some anhydrides in chloroform solution, by M. Marcel Desfontaines.—On the opisthobranchs collected in 1883 by the Talisman expedition, by M. A. Vayssière.—The lymphomyeloid constitution of the conjuctive stroma of the testicle of the young in *Raja clavata*, by M. A. Policard.—On the homologies of the interstitial cell of the testicle, by M. P. Stéphan. —On the structure of the tuberculous roots of *Thrincia tuberosa*, by MM. A. Maige and C. L. Gatin.—On the *Ksopo* or *Tanghin de Ménabé*, the poison of *Menabea venenata*, by M. E. Perrot. —The chemical study of Flamanville granite, by M. A. Leclère. It is shown from the analyses given that the composition of an eruptive rock may differ very considerably in certain cases from that of the initial magma.—On the transformation of fatty materials into sugars in oleaginous seeds during germination, by M. P. Mazé. The experiments afford confirmation of the view that the digestion of fatty matters in the seed during germination is made with a slow fixation of oxygen, and, probably, with a slight loss of carbon.—Researches on the working of antagonistic muscles in voluntary movements, by M. I. Athanasiu.—Remarks on a note of M. Pizon on a mechanical theory of vision, by M. Raphael Dubois. In reply to the criticism of M. Pizon, the author maintains that his mechanical theory of vision is confirmed, not only by the researches of Deren Stort and Engehlmann, but also by those of Charpentier and d'Arsonval.—The vine and *Coepophagus echinopus*, by M. S. Jourdain. MM. L. Mangin and P. Viala have correlated a certain disease of the vine with the presence of a certain acarian, *C. echinopus*. The author advances reasons for doubting the correctness of this view, and believes that curative measures directed against this acarian will be useless.—A new case of trichosporia observed at Nancy, by M. Paul Vuillemin.—Contribution to the knowledge of the action of lecithine on the typical elements of the blood, by MM. H. Stassano and F. Billon.—The etiology of the cattle plague, by MM. Nicolle and Adil-Bey.—On a fall of rain observed at Périers, by M. Sebillaut. The rain-water from the shower in question was found to contain chalk, sulphates, chlorides and silica, the latter in sufficient quantity to cover the leaves of trees with a siliceous layer.

DIARY OF SOCIETIES.

THURSDAY, FEBRUARY 13.

ROYAL SOCIETY, at 4.30.—On the Sub-Mechanics of the Universe: Prof. O. Reynolds, F.R.S.—On Chemical Dynamics and Statics in Light: Dr. M. Wilderman.—Preliminary Note on a Method of Calculating Solubilities, Equilibrium Constants of Chemical Reactions, and Latent Heat of Vaporisation: Dr. A. Findlay.—The Refractive Indices of Fluorite, Quartz and Calcite: J. W. Gifford.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Researches on the Electrical Conductivity and Magnetic Properties of upwards of 100 different Alloys of Iron: Prof. W. F. Barrett, F.R.S., and W. Brown.—On some Conclusions deduced from the preceding Paper: Prof. W. F. Barrett, F.R.S.

MATHEMATICAL SOCIETY, at 5.30.—(1) On the Density of Linear Sets of Points; (2) On Closed Sets of Points defined as the Limit of a Sequence of Sets of Points: W. H. Young.—On Plane Cubics: Prof. A. C. Dixon. —On Boussinesq's Problem: Prof. H. Lamb, F.R.S.—On the Wave Surface of a Dynamical Medium, Æolotropic in all Respects: Prof. T. J. Bromwich.—On Quantitative Substitutional Analysis (second paper): A. Young.

FRIDAY, FEBRUARY 14.

ROYAL INSTITUTION, at 9.—Magic Squares and other Problems on a Chess Board: Major P. A. MacMahon, F.R.S.

PHYSICAL SOCIETY, at 5.—Annual General Meeting.—Address by the President, Prof. S. P. Thompson, F.R.S.—Mr. T. H. Littlewood will exhibit an Atwood's Machine.

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

MALACOLOGICAL SOCIETY, at 8.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Some Public Health Aspects of the Question of Sewage Disposal: C. Johnston.

SATURDAY, FEBRUARY 15.

ROYAL INSTITUTION, at 3.—Some Electrical Developments: Lord Rayleigh, F.R.S.

MONDAY, FEBRUARY 17.

SOCIETY OF ARTS, at 8.—Personal Jewellery from Prehistoric Times: Cyril Davenport.

IMPERIAL INSTITUTE, at 8.30.—The Obstacles to Development in West Africa: Dr. C. F. Harford-Battersby.

VICTORIA INSTITUTE, at 4.30.—The Physical History of the Norwegian Fjords: Prof. Edward Hull, LL.D., F.R.S.

TUESDAY, FEBRUARY 18.

ROYAL INSTITUTION, at 3.—The Cell: its Means of Offence and Defence: Dr. A. Macfadyen.

ZOOLOGICAL SOCIETY, at 8.30.—On *Mustela palaeattica* from the Upper Miocene of Pikermi and Samos: Dr. C. I. Forsyth Major.—On Two New Genera of Rodents from Potosi, Bolivia: Oldfield Thomas, F.R.S.—On some Characters distinguishing the Young of various Species of Polypterus: G. A. Boulenger, F.R.S.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Electrical Traction on Railways: W. M. Mordey and B. M. Jenkin.

ROYAL STATISTICAL SOCIETY, at 5.—A Statistical Review of the Income and Wealth of British India: J. Atkinson.

WEDNESDAY, FEBRUARY 19.

SOCIETY OF ARTS, at 8.—The Use of Balloons in War: E. H. S. Bruce.

ROYAL METEOROLOGICAL SOCIETY, at 7.30.—Report on the Phenological Observations for 1901: E. Mawley.—La Lune mange les Nuages —a Note on the Thermal Relations of Floating Clouds: W. N. Shaw, F.R.S.

CHEMICAL SOCIETY, at 5.30.—Enzyme Action: A. J. Brown.—On the Velocity of Hydrolysis of Starch by Diastase, with some Remarks on Enzyme Action: H. T. Brown and T. A. Glendinning.—Polymerisation Products from Diazoacetic Ester: O. Silberrad.—Condensation of Phenols with Esters of Unsaturated Acids, Part VII.: S. Ruhemann and H. E. Stapleton.—The Union of Hydrogen and Oxygen: H. B. Baker.

ROYAL MICROSCOPICAL SOCIETY, at 8.—Polarising with the Microscope: E. M. Nelson.

THURSDAY, FEBRUARY 20.

ROYAL SOCIETY, at 4.30.

LINNEAN SOCIETY, at 8.—(1) On some Gasteropoda (*Limnotrochus* and *Chitra*) from Lake Tanganyika, with the Description of a New Genus; (2) On the Nyassa Vivipara and its Relationship to Neothauma: Miss L. Digby.—On the Fruit of *Melocarina bambusoides*, an Exalbuminous Grass: Dr. A. Stapf.—On a West Indian Sea Anemone, *Bunodeopsis globulifera*: Dr. J. E. Duerden.

FRIDAY, FEBRUARY 21.

ROYAL INSTITUTION, at 9.—Musical and Talking Electric Arcs: W. Duddell.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Annual General Meeting. Followed by discussion on Modern Machine Methods, with Reply by the Author, H. L. F. Orcutt, and, time permitting, Fencing of Steam- and Gas-Engines: H. D. Marshall.—Fencing or Guarding Machinery used in Textile Factories: S. R. Platt.—Protection of Lift-Shafts, and Safety Devices in connection with Lift-Doors and Controlling Gear: H. C. Walker.—Guarding Machine Tools: W. H. Johnson.

GEOLOGICAL SOCIETY, at 3.—Annual General Meeting.

EPIDEMIOLOGICAL SOCIETY, at 8.30.

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