THURSDAY, APRIL 26, 1888.

MR. A. C. SMITH'S "BIRDS OF WILTSHIRE."

The Birds of Wiltshire, comprising all the Periodical and Occasional Visitants, as well as those which are indigenous to the County. By the Rev. Alfred Charles Smith, M.A. (London: Porter, 1887.)

BY all ornithologists Wiltshire will be admitted to be a county the birds of which are worthy of a volume; and all ornithologists, who know, even by name and reputation only, Mr. Alfred Charles Smith, will admit that he of all men is the proper author of that volume. Nominally but the Honorary Secretary of the Wiltshire Archæological and Natural History Society, the Rector of Yatesbury has for many years past been its most active officer, and the editor of its organ—the *Wiltshire Magazine*—to say nothing of the various "by-blows" of which he has at times been delivered in the shape of "Tours" in Portugal, Egypt, and Palestine, or of the very laborious and important work on the "British and Roman Antiquities of the North Wiltshire Downs"—that work which so narrowly escaped total destruction—nearly all the copies of the original edition having perished by a disastrous fire while in the binders' hands. Mr. Smith, too, is a Wiltonian of the Wiltonians; not only one of the best-known and most highly-esteemed men in his own county, but one of those who, in these days of universal brotherhood and cosmopolitan sympathies, are year by year becoming rarer. Hence he speaks from the heart when he expresses himself as in his opening paragraphs:—

"The county of Wilts has been sometimes thoughtlessly said to be poor in Ornithology; indeed, I have heard it denounced by superficial observers as exceptionally wanting in the various members of the feathered race; pre-eminent, doubtless, in the remains of antiquity—so these gentlemen are good enough to allow—but in birds a barren field indeed. Against any such verdict I enter a decided protest, and I even maintain, on the contrary, that, taking into consideration that Wiltshire is an inland district, and therefore cannot be expected to abound in birds whose habitat is the sea and the sea-shore, our county will scarcely yield to any other, similarly situated, in the number and variety of the species of birds to be found there; and I now proceed to prove this by statistics.

"Let us first, however, examine the physical aspect of Wiltshire, and we shall see that it is not composed of bleak open downs alone, as its detractors superciliously affirm, but that it can show a great diversity of scenery, and much of it of surpassing beauty. We have, it is true, our broad, open, expanding downs—and what native of Wiltshire does not glory in them and admire them?—but we have at the same time our richly-timbered vales: if we have hill, we have also dale; if we have open plains, we have also large woods and thick forests. Where shall we find more clear and limpid streams, where more green and laughing meadows, than in the valley of the Avon (the northern and southern Avon), the vale of Kennet, or of Pewsey, or of Wily, or of Wardour? Where, again, in all England can we meet with a forest to compare with that of Savernake? And in woods and parks and well-timbered estates, both in the north and south of the county, we are exceptionally rich" (pp. 1, 2).

All who have traversed Wiltshire will readily allow the truth of these words, skilfully put together as they are by our author, in regard to the pleasing variety which its landscape in several parts exhibits, yet it must be confessed that the variety is limited in extent—the same features recurring over and over again, so that one range of downs or one valley repeats another. Both down and valley are alike enjoyable to the utmost, but the contrast between them is mild when compared with that afforded by hill and dale in many another county; and, above all, whatever may be the reason of it, Nature in Wiltshire wears an aspect of sameness, which, after a few days, becomes almost distressing to the stranger, because it is disappointing, though the native may very likely rejoice in the absence of everything that suggests a wild country; and a wild country, it should be needless to observe, gives the hope, if not its realization, of a plentiful crop of birds.

Though we fully admit the strong temptation to which a faunistic writer is exposed of magnifying the area of his field of work, it has been our duty before now in these columns to condemn the inconsiderate yielding to that temptation; and, with the utmost regard for our present author, we are compelled to say that he has fallen—perhaps not so deeply as others—into this besetting sin. We must repeat what we have so often urged before. The real interest (not only scientific, but even sentimental) of a fauna lies in its proper inhabitants—those that are entitled to all the rights and privileges of citizenship—and not in those adventitious aliens,

'Blown from over every main"

—strangers which are the sport of fate, and to whom the offer of letters of naturalization is not only a mockery—for if chance allows they are invariably killed—but an insult to the rightful denizens of the district. However, even on the unprincipled principle—which, by the way, is only admitted in ornithology among all the many branches of natural history—that a species once showing itself in a district should be scored to that district's credit, some proof of the alleged appearance is needed before it be accepted as a fact. Experience proves that there are few compilers of faunas, especially ornithological faunas, who are not ready, we will not say to strain a point, but to receive favourable evidence on easy terms; and indeed a rigid examination of all claims to admission, with a stern rejection of those that cannot be substantiated, is a virtue which has hardly been cultivated until within these later days, and not often even recently.

We have just said that in this respect Mr. Smith is not a grievous sinner; and, after examining his list pretty carefully, we find but sixteen species that we think ought, almost without any doubt, to be excluded on one ground or another—whether the ground be insufficient testimony, manifest importation, or from their proper habitat being so far distant as to render it nearly certain that their recognition within the boundaries of the county was only the accident of an accident. But how much stronger would Mr. Smith's list be if these sixteen species were omitted? and how much stronger still if the (say) forty irregular visitants were also subtracted? Then, and only then, would the ordinary reader know the wealth of Wiltshire ornithology; and, for an inland county, presenting (as we have stated) a not very diversified area, and mainly composed of one geological formation, a very respectable comparison could be made, we are confident, with any other county, however favourably situated. We are not going to make the calculation—indeed, for comparison's sake, the statistics of many other counties are as yet wanting; but we think it would appear that not many English shires would show a more creditable roll of real inhabitants, whether breeding within its borders, or so regularly visiting it at fixed seasons as to deserve recognition as denizens. Of the former, we think Wiltshire could fairly claim 100, and of the latter 50, making the respectable number of 150, to which might be added 29 for irregular visitants to be legitimately included, after deducting the aforesaid (16 + 40 =) 56 from Mr. Smith's total of 235. Our author may think very hardly of us for thus diminishing the ornithic wealth of his county, but we assure him that he would have little cause to complain of the result were the same rule applied to the so-called "avifaunæ" of other inland shires.

This, however, is a theme we will not pursue. Rather let us speak of the manifest merits of Mr. Smith's volume. One of them stands out pre-eminently in that he has accorded so much space to two species very interesting to all who care for English birds—the Raven and the Heron. Of the former, which in days not so long past had numerous homes in Wilts, an account is given which in years to come will, we are sure, be regarded as of the highest interest, for it is compiled from information obtained by no fewer than 110 correspondents in various parts of the county, and is in itself a proof of well-directed energy. The result is, of course, a mournful one.

"It will be seen that the history of the Ravens of Wiltshire is, alas! rather a history of that which is past and gone than of that which is flourishing to-day; so persecuted, shot down, trapped, and despoiled of their young have these noble birds been at the hands of ruthless gamekeepers and others, who have gone upon the false issue that they are very destructive to game, whereas, with the exception of an occasional raid on a leveret or a rabbit, they do little harm in the preserves, for the Raven cannot bear an inclosed district—he must have plenty of room to disport himself; and as to being 'cabin'd, cribb'd, confin'd' within narrow woods, he eschews them altogether, and only during the breeding-season will he consent to occupy some big tree in the park, generally the highest and most inaccessible he can find, and there he and his mate return, year after year, to occupy their accustomed nursery" (p. 222).

It would seem, from Mr. Smith's information, that out of the twenty-two localities he names, sixteen have wholly ceased to be tenanted by this species, four are doubtful, and in *two* only has the bird certainly still a home. But how many English counties could claim such a distinction as that? Some of the larger landowners, as the Duke of Beaufort, Lords Bath and Pembroke (to their credit be it said), have been disposed to protect this very interesting and (as the writer from his own experience can assert) comparatively harmless species; but gamekeepers' prejudices are almost beyond control, and probably nothing short of a reward given on the hatching-off of a ravenry, combined with dismissal on the murder of a breeding-bird, would insure protection. A scientific man naturally shuns sentiment as such, but curious it is that the owners of historic estates do not perceive the value of all their historic associations; and an ancient Raven-tree, still occupied by the descendants of many a generation, would be no mean adjunct to the glories of Badminton or Bowood, Longleat or Wilton! Where the proprietor does not exert himself, the doom of the species is as certain as that of the Bustard has proved to be.

The Bustard, in popular opinion, is always more associated with the Wiltshire Downs or Salisbury Plain than with any other part of England. But needless to observe that herein, as usual, popular opinion is wrong, and anyone who seeks will find that in reality the association terminated much longer ago than in four or five other counties. Mr. Smith naturally devotes a good deal of space—much of it being, we regret to say, wholly beside the purpose—to this grand bird; and indeed its gilt figure decorates the cover of his volume. We must, however, express ourselves somewhat disappointed at the result, though it is one not unexpected. The statements of the editor of Pennant in 1812, and of Montagu in 1813, are confirmed, and in a small degree supplemented; but, says our author:—

"After this I have no record on which I can rely of any native Wiltshire Bustard; but I have had many statements, to which I listened attentively, from thirty to forty years ago, from old shepherds, farmers, and labourers, several of whom could well recollect seeing these birds on the downs in their early days, but from whom I could obtain no reliable information as to date; for the Wiltshire countryman, good honest soul, is not observant of detail, and as to dates he ignores them altogether—'a long whiles ago' conveniently covering half a century. However, by putting together the information gained from many sources, and by comparing the several statistics which I thought reliable, I arrived at the opinion (perhaps somewhat indistinct and hesitating) that our Wiltshire Bustard lingered on till about the year 1820" (pp. 355, 356.)

This date may be approximately correct; but it is undeniable that for several years later the Bustard inhabited the Wolds of Yorkshire and Lincolnshire, and was not extirpated in Suffolk in 1832, nor in Norfolk until 1838; since which time all the examples that have occurred in England (Wiltshire included) may rightly be regarded as foreign visitors.

Mr. Smith's account of the Heron, before mentioned, is as satisfactory as that which he gives of the Raven; but here it must suffice to say that Wiltshire boasts of seven heronries, besides twenty-two offshoots. Some of the former, however, are but recently established, and fresh colonies are always forming; for in this county, as elsewhere in England, is observable the tendency of these birds to break up and colonize—a fact almost undoubtedly due, as has been pointed out by more than one writer, to the increased difficulty of finding in one spot food for their young, induced by the more complete drainage of the country.

We have left ourselves no space for other matters on which we should like to dwell, as the honest enthusiasm of our author makes us a little blind to his faults—whether of omission or commission—the latter certainly predominating; for in his desire to give information to his readers he says a great deal more than is necessary in a faunistic work, especially as to classification, nomenclature, structure, and so forth—all matters that are best left to experts, and their treatment (which is far from perfect) only swells the volume to an uncomfortable size. We also freely excuse his many old-fashioned ways, which will, however, be no blemish, if they be not a positive blessing, in the eyes of most of his readers. The most severe critic must admit that the style, without being in the least laboured, is far superior to that of the ordinary writer on natural history, and the book is consequently in the highest degree readable. Many a Wiltshire man, woman, and child will have reason to be grateful to Mr. Alfred Charles Smith.

A HAND-BOOK FOR TRAVELLERS.

Führer für Forschungsreisende. Anleitungen zu Beobachtungen über Gegenstände der physischen Geographie und Geologie. Von Ferdinand Freiherr von Richthofen. (Berlin: Oppenheim, 1886.)

IT is now thirteen years since Dr. Neumayer issued his "Anleitung zu wissenschaftlichen Beobachtungen auf Reisen," a joint production of himself and representatives of various departments of science, the geological section having been contributed by the present author. The volume now under consideration is virtually an enlarged and completely revised edition of that section, which it seemed desirable to publish separately. A re-issue of the complete work is, however, in contemplation. The qualifications which Von Richthofen possesses for the task he has undertaken are of no common order. Himself a traveller of wide experience, whose work on China deservedly ranks as one of the classics of geographical literature, he brings to bear upon his subject a wealth of practical knowledge combined with scientific attainment, in which few are his equals.

In the preface it is explained that the primary object of the work is to enable those travellers whose previous scientific training is not extensive, such as missionaries, merchants, and others, who may be thrown in regions but little explored, to make observations which shall be of permanent value. Under these circumstances, no attempt is made to furnish the reader with references to the literature of the subject which would almost certainly be inaccessible to him, although notice is taken here and there of modern treatises on particular questions. The body of the work opens by an introduction, the scope of which may best be indicated in a general way by stating that it contains such headings as "Outfit," "Modes of Travelling," and "Miscellaneous Practical Hints." These last are especially valuable, and might with advantage be carefully studied by anyone who is starting on a first expedition, on account of their eminently suggestive and practical character. The emphasis laid upon the necessity of noting all observations on the spot, and even upon such minutiæ as having the pencil suspended round the neck so as to be always ready, indicates an experience of the temptations to procrastination which beset travellers in common with humanity at large. Among other divisions of this section may be mentioned "Measuring and Drawing," in which sufficient directions are given for mapping unexplored countries in a preliminary fashion, and also "Climatic and Biological Observations," the latter of which are treated with extreme brevity, as not falling within the author's special province.

The next portion of the book is entitled "Observations upon Externally Modifying Processes," and includes chapters upon rocks and soils, on springs and flowing water. It contains a dissertation of some length on the important subject of glaciers, in which the phenomena accompanying their present existence, as well as the traces of their past action, are carefully described. In another chapter an abstract is given of the present state of our knowledge regarding coral reefs and islands. In addition to the time-honoured theory of Darwin, the most recent researches of Semper, Rein, Murray, and Studer are summarized; one misses, however, the name of Agassiz in this connection, and it is noticeable that, although Dana's soundings off Tahiti are quoted in some detail, no mention is made of the series executed by the *Challenger*, although their results agree well with the author's diagrammatic section of a reef. No one theory is embraced to the exclusion of all others, but stress is laid upon the need for further investigation, and upon the fact that "each reef has its own special history of origin and development." Upraised coral reefs are indicated as being likely to throw light on the question—a suggestion which has been independently carried out by Dr. Guppy in the Solomon Islands with such brilliant results. A few pages give what is known regarding the changes of level of the ocean, and the terms "positive" and "negative displacement" are adopted instead of "sinking" and "upheaval" of the land respectively.

The third section is devoted to "Observations on the Crust of the Earth, on Rocks, and on Mountain Structure." It contains an outline of the principal facts of petrology and of stratigraphical geology.

The author treats his subject in considerable detail; his volume occupies more than 700 pages—that is, a somewhat larger bulk than the whole of Neumayer's original work. Indeed, if a fault is to be found in the book, we should be disposed to say that, considering the fact that only one aspect of Nature is discussed, the amount of detail is rather excessive. If botany, zoology, anthropology, and all the other matters which have an equal claim upon the traveller's attention, were elaborated in the same fashion, the result would be an encyclopædia of no small dimensions. The work is, however, thoroughly practical in character. There are no lengthened discussions upon abstract questions, but divergent theories regarding unsettled points are summarized in such a way as to indicate how both the traveller who has time at his disposal, and also he who is compelled to hasten through the country, can each make the best use of their respective opportunities.

W. E. H.

OUR BOOK SHELF.

Geometry in Space. Edited by R. C. J. Nixon, M.A. "Clarendon Press Series." (London: Henry Frowde, 1888.)

THIS book is a sequel to "Euclid Revised" by the same author. It consists of one hundred pages, divided into three chapters and an appendix. The first chapter is devoted to the discussion of planes and solid angles, covering much the same ground as Euclid's eleventh book; it contains, besides, some very useful notes on elementary perspective and the drawing of solid figures. This is an excellent feature of the book, and the author might with advantage have given more than a couple of pages to it, for there is no doubt that, to most students, the representation of solid figures, other than the simplest, is a real and often a permanent stumbling-block to the development of the science in their own minds. The second chapter is concerned with polyhedra. It begins with Euler's theorem establishing a linear relation between the numbers of edges, corners, and faces, and Listing's extension of it. In giving the latter the author speaks of "facets," "sheets," and "interfaces," without having previously defined them, thus leaving a student in some little difficulty as to their precise meaning. Considering the great analytical interest of the algebraical researches of Klein and Cayley in the polyhedral functions and the finite groups of linear substitutions, which represent geometrically the production of congruence of figure by the rotations of the corresponding polyhedra, we think it would add greatly to the interest of the book to show the elementary geometrical relations which interpret the algebraical operations. The mensuration and usual properties of the simple solids are worked out, the method of limits being freely employed. The third chapter is of "Solids of Revolution," and includes Pappus's theorems of mensuration, the extension of the modern geometry of lines and circles to planes and spheres, and an elementary account of surface spherics.

The appendix, which treats of the "Geometrical Theory of Perspective in Space," is from a paper in the *Quarterly Journal of Mathematics* for 1886, by Mr. Alexander Larmor, of Clare College, Cambridge; it contains ten important theorems in the subject.

Throughout the book great brevity of expression is employed with taste and discretion. It bears traces of careful compilation, and is certainly well and suitably printed and illustrated. Interesting theorems and problems are given as exercises at the end of each chapter.

The work may be safely recommended to students and teachers as a clear and precise introduction to the study of solid geometry.

Chambers's Encyclopædia: a Dictionary of Universal Knowledge. (London: William and Robert Chambers, 1888.)

THE process of revising and altering a work of this kind is no easy task. As the publishers tell us, "much has happened during the twenty years it has been before the public which necessitates a different treatment of many articles." This new edition has been thoroughly revised, new articles having been written, and the old ones gone over by eminent authorities, as may be seen from the following list: Alchemy and Atomic Theory, by Prof. Crum-Brown; Ant, by Sir John Lubbock; Alps, by Prof. James Geikie; Arctic, Antarctic, and Atlantic Oceans, by Mr. John Murray; and Atom, by Prof. Tait. While such well-known names as these will command universal respect and confidence, it is to be regretted that some of the subjects, such as that of Astronomy—to take an instance—should leave much to be desired in this particular.

The work is carried out on exactly the same lines as the original edition, the subjects being treated, not in great detail, but so as to afford information interesting to any more or less educated person.

American and colonial subjects are dealt with in this edition more than in former ones, the more important articles on American subjects being written by American authors especially for this re-issue.

The number of maps, both geographical and physical, has been increased, and the illustrations are more numerous, and supersede those of former editions. The printing throughout is excellent.

Messrs. Chambers are to be congratulated upon the issue of a work which, from its merits, deserves to find a place in every home.

Leitfaden der Zoologie für die oberen Classen der Mittelschulen. Von Dr. Vitus Graber. Mit 502 Abbildungen im Texte (darunter 62 farbige) und einem Farbendruckbilde. (Wien: F. Tempsky, 1887.)

EVEN in these days of cheap books, it is surprising to find an octavo volume of nearly 250 pages, with over 500 illustrations, published for the price of less than three shillings of our money. When we add that the information, though of necessity very much condensed, is not only good and exact, but in most cases quite up to date, we have said all that is needed to call our readers' attention to this little volume.

The coloured illustrations in the text are wonderfully effective; one gives a representation of one of Schulze's sections through a Sponge, printed in two colours, in which the horny framework is represented yellow, the pore-canal system blue.

It is interesting to note that at a time when in this country the study of biology is not encouraged in our schools, when it is omitted from the programme of our intermediate education examinations, it should be so taught in the intermediate schools in Austria as to call for the production of such an excellent and cheap introduction to its study.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

"Coral Formations."

I SHOULD be trespassing too much on the kindness of the Editor of NATURE if I were to refer to all the numerous novel and interesting points in Mr. Bourne's description of Diego Garcia. The retrospective character of the account is something new in the instance of an atoll; and it is not often that a naturalist is able to add to his own observations the twenty-five years' experience of an observer like M. Spurs.

I am, however, at a loss to understand why Mr. Bourne is unable to assent to the theory of subsidence. Prof. Dana, who long since referred to the evidence of upheaval in the atoll regions of the Pacific, nevertheless did not regard such evidence as negativing the theory he supported, nor, in fact, did Mr. Darwin himself. The testimony most required to overturn the theory of subsidence is the testimony which the supporters of that view will accept. I do not find such evidence in Mr. Bourne's paper.

I am also in doubt as to the position of the writer of the paper in regard to Mr. Murray's views. In disagreeing with the importance which Mr. Murray attaches to the agency of solution, he makes no attack on the main position of the new explanation, viz. the building up of the foundations of atolls by organic deposits. Does Mr. Bourne accept this view?

H. B. GUPPY.

I HAVE been much interested by the discussion on coral formations which recently appeared in NATURE, and I venture to send you an extract from a journal kept during my stay in Massowah.

"*Massowah, February* 1888.—The whole of the harbour is fringed with coral reefs formed by species of *Madreporaria* (*perforata*), extending in places a considerable distance from the high-water mark (Turtle Island, for example); in other parts the edge of the reef is quite close to land, and in each case there is less water immediately over the edge of the reef than there is a little way in shore. The outer edges of the reefs go down almost perpendicularly to a depth of 4 or 5 fathoms, while towards the shore the water deepens, at first rather quickly to 3 or 4 feet, then gradually becomes shallow to the beach. The bottom, inside the edges of the reefs, is composed of fine grayish mud—composed chiefly of a mixture of disintegrated coral and fine drift alluvial sand which is blown over from the mainland—while the bottom of the harbour is nearly black mud. Here and there, just inside the edges of the reefs, are found pieces of living coral broken off from the outer edges. Every evidence here shows that the land is rising.

"Large masses of coral much altered by the rain are to be found on the plains of Massowah, which extend three or four miles in south-west, west, and north-west directions. They show unmistakable signs of the undermining action of the sea, which can still be seen going on around the coast and harbour. At Mokullo, at a depth of 20 feet, I observed masses of coral (*Aperosa*) almost perfect in shape, covered up with alluvium. It is probable that the whole coast from the mountains has been reclaimed by the action of coral builders, and that eventually the group of islands outside will be joined to the mainland."

I noticed a similar formation of the coral reefs in Suakim Harbour; while at Key West, Florida, there was no lessening of the depth of the water on the edge of the reefs.

DAVID WILSON-BARKER.

THE following table, showing some of the results of work done in connection with the solubility of carbonate of lime in sea-water will be of interest. The difference in solubility between heavy dense corals and the lighter porous varieties is very marked.

TABLE I.—*Showing Solubility of Carbonate of Lime, under different forms, in Sea-water, in grammes per litre.*

Material used.	Temperature.	Exposure.	Mean amount of $CaCO_3$ taken up.	Number of determinations made.
	° C.	Hours	Grm.	
Dead coral, Porites	27	12	0·395	3
Coral sand	27	12	0·032	5
Harbour mud, Bermuda	27	12	0·041	2
Isophyllia dipsacea (Dana), Bermuda	27	12	0·041	6
Millepora ramosa (Pallas), Bermuda	27	12	0·036	7
Madrepora aspera (Dana), Mactan Island, Zebu	27	12	0·073	7
Montipora folioso (Pallas), Amboyna	27	12	0·043	7
Gomastræa multilobata (Qualch), Amboyna ...	10	12	0·073	3
Porites clavaria (Lamk.), Bermuda	10	12	0·093	2

TABLE II.

Weathered oyster-shells	10	12	0·331	3
Mussels allowed to rot in sea-water seven days...	27	168	0·384	2
Crystallized carbonate of lime	10	12	0·123	2
a Amorphous carbonate of lime (freshly prepared)	10	—	0·649	2
b Ditto ditto ditto	−1·66	—	0·610	2
Melobesia, Kilbrennan Sound, Scotland ...	10	12	0·089	3

a and *b*. The carbonate of lime was added as long as it dissolved.

The figures in Table II. will give Mr. T. Mellard Reade facts (so far as laboratory experiments may) upon which to found reasonable views. Mr. George Young, who has made all the determinations under my direction, is one of the chemical staff attached to the Marine Station here.

ROBERT IRVINE.

Royston, Granton, near Edinburgh, April 16.

Note on a Problem in Maxima and Minima.

I SUPPOSE most lovers of elementary geometry who read the communication on the above subject from Mr. Chartres in NATURE of February 2 (p. 320) admired the simple investigation he gave of the problem.

I should like, however, to point out—

(1) That it might be made still more elementary by proving EB + EC = ED without the aid of Book VI.

Let E be any point on the arc of the circumcircle of an equilateral triangle BDC on which the angle D stands, and on ED as diameter describe a circle cutting EB, EC in B′, C′.

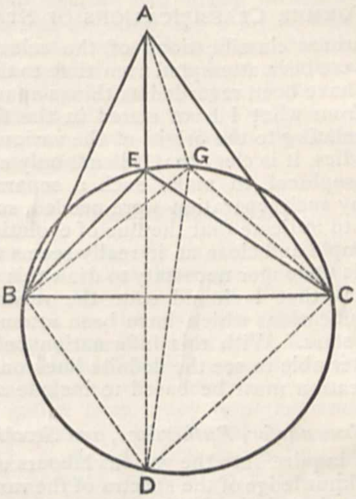
$$\text{Then } \angle B'C'D = \angle BED = \angle BCD.$$
$$\text{Similarly } \angle C'B'D = \angle CBD;$$
$$\therefore \angle B'DC' = \angle BDC;$$
$$\therefore B'C'D \text{ is equilateral.}$$

Hence B′E, EC′ are sides of a regular hexagon inscribed in the circle B′C′D.

$$\therefore B'E + EC' = ED.$$
$$\text{Again, } BD, DB' = CD, DC',$$
$$\text{and } \angle BDB' = \angle CDC';$$
$$\therefore BB' = CC';$$
$$\therefore BE + EC = B'E + EC' = ED.$$

(2) If we assume Ptolemy's theorem (conventionally quoted as Euclid, VI. D) we may as well assume the known extension of it to acyclic quadrilaterals given in Todhunter's "Euclid," p. 318, and at the same time generalize the problem thus—

To find a point E within a triangle such that l . AE + m . BE + n . CE may be a minimum; l, m, n being such that any two are together greater than the third.



On BC describe a triangle BCD such that BC : CD : DB :: $l : m : n$; the point required will be the intersection E of AD with the circumcircle of BCD if E is within the triangle ABC.

$$\text{For } BE \,.\, CD + CE \,.\, BD = ED \,.\, BC,$$
$$\therefore m \,.\, BE + n \,.\, CE = l \,.\, ED;$$
$$\therefore l \,.\, AE + m \,.\, BE + n \,.\, CE = l \,.\, AD.$$

But if G is any other point on the arc BEC,

$$m \,.\, BG + n \,.\, CG = l \,.\, GD;$$
$$\therefore l \,.\, AG + m \,.\, BG + n \,.\, CG = l \,.\, AG + l \,.\, GD;$$
$$\therefore l \,.\, AG + m \,.\, BG + n \,.\, CG > l \,.\, AD.$$

And if P be any point within the triangle ABC, but not on the circumference—

$$BP \,.\, CD + CP \,.\, BD > PD \,.\, BC \text{ (Todhunter's "Euclid," [p. 318]);}$$
$$\therefore m \,.\, BP + n \,.\, CP > l \,.\, PD;$$
$$\therefore l \,.\, AP + m \,.\, BP + n \,.\, CP > l \,.\, AP + l \,.\, PD;$$
$$\therefore l \,.\, AP + m \,.\, BP + n \,.\, CP > l \,.\, AD.$$

If l, m, n are proportional to a, b, c, E is the orthocentre of ABC.

If l, m, n are proportional to c, a, b, or b, c, a, E is one of the Brocard points of ABC, and the construction for E is equivalent to that of Mr. R. F. Davis for the Brocard points ("Reprint of Mathematics from the *Educational Times*," vol. xlvii. App. II.).

It will, of course, be seen that the triangle formed by drawing perpendiculars to AE, BE, CE through A, B, C, is the maximum triangle with its sides proportional to l, m, n and passing through A, B, C. Prof. Genese has kindly supplied me with an elementary investigation of the problem, depending on the construction of that triangle.

It may also be seen that the question has an intimate connection with one proposed by Mr. Morgan Jenkins in the *Educational Times* for August 1, 1884:—

If on the three sides of a triangle, ABC, there be described any three triangles, BDC, CEA, AFB, either all externally or all internally having their angles in the same order of rotation, and the angles which are contiguous to the same corner of ABC equal to each other, prove that AD, BE, and CF meet in a point O, which is also the common point of intersection of the circumcircles of BDC, CEA, AFB ("Reprint," vol. xliii. pp. 88–91).

EDWARD M. LANGLEY.

Bedford, April 14.

Self-Induction.

I FIND I am being quoted as having said that an iron conductor has less self-induction than a copper one. You will perhaps spare me a line to disclaim any such statement. It is one which seems to me on the face of it absurd.

OLIVER J. LODGE.

SUGGESTIONS ON THE CLASSIFICATION OF THE VARIOUS SPECIES OF HEAVENLY BODIES.[1]

II.

II.—CLASSIFICATION.

I. Former Classifications of Stars.

In the various classifications of the celestial bodies which have been attempted from time to time, nebulæ and comets have been regarded as things apart from the stars; but from what I have stated in the first part of this paper, relating to the origin of the various groups of heavenly bodies, it is clear that it is not only unnecessary but unphilosophical to make such a separation; and indeed, if any such separation were needed, such a result would seem to indicate that the line of evolution is by no means so simple and clear as it really seems to be. But although it is no longer necessary to draw this distinction, it is important that I should state the various spectroscopic classifications which have been attempted in the case of the stars. With this information before us, we shall be better able to see the definite lines on which any new classification must be based to include all celestial forms.

Fraunhofer, Rutherfurd, and Secchi.

When we inquire into the various labours upon which our present knowledge of the spectra of the various orders of "stars" are based, the first we come across are those of Fraunhofer, who may be said to have founded this branch of scientific inquiry in the year 1814.

Fraunhofer not only instituted the method of work which now is found to be the most effective, but his observations at that time were so excellent that he had no difficulty in finding coincidences between lines in the sun and in Venus.

Fraunhofer's reference to his observations runs as follows:—

"I have also made several observations on some of the brightest fixed stars. As their light was much fainter than that of Venus, the brightness of their spectrum was consequently still less. I have nevertheless seen, without any illusion, in the spectrum of the light of Sirius, three large lines, which apparently have no resemblance with those of the sun's light. One of them is in the green, and two in the blue space. Lines are also seen in the spectrum of other fixed stars of the first magnitude; but these stars appear to be different from one another in relation to these lines. As the object-glass of the telescope of the theodolite has only thirteen lines of aperture, these experiments may be repeated, with greater precision, by means of an object-glass of greater dimensions."[2]

He did not attempt to classify his observations on stellar spectra, but, as pointed out by Prof. Dunér ("Les Étoiles à Spectres de la Troisième Classe," p. 3), those that he most particularly mentions are really remarkably diverse in their characteristics.

In these researches Fraunhofer was followed by Rutherfurd, who, in the year 1863, was the first to indicate that the various stellar spectra which he had then observed were susceptible of being arranged into different groups. His paper was published in *Silliman's Journal* (vol. xxxv. p. 71), and, after giving an account of the observations actually made, continues as follows:—

"The star spectra present such varieties that it is difficult to point out any mode of classification. For the present, I divide them into three groups:—First, those having many lines and bands, and mostly resembling the sun, viz. Capella, β Geminorum, α Orionis, Aldebaran, γ Leonis, Arcturus, and β Pegasi. These are all reddish or golden stars. The second group, of which Sirius is the type, presents spectra wholly unlike that of the sun, and are white stars. The third group, comprising α Virginis, Rigel, &c., are also white stars, but show no lines; perhaps they contain no mineral substance, or are incandescent without flame."

Soon afterwards Secchi carried on the inquiry, and began in 1865 by dividing the objects he had then observed into two types. These two types were subsequently expanded in 1867 into three ("Cataloge delle Stelle di cui si e determinato lo Spettro Luminoso," Secchi, Parigi, 1867): first, white stars, like α Lyrae; secondly, yellow stars, like Arcturus; and, thirdly, deeply coloured stars, like α Herculis and α Orionis. The order of these types was not always as stated, but I have not been able to find the exact date at which the order was changed (Dunér, "Sur les Étoiles," p. 128). Secchi subsequently added a fourth type, in which the flutings were less numerous. There is little doubt that Secchi was led to these types not so much by any considerations relating to the chemical constitution of the atmospheres of these bodies as in relation to their colours. His first classifications, in fact, simply separated the white stars from the coloured ones (see on this point "Le Scopirte Spettroscopiche," P. A. Secchi, Roma, 1865).

The fourth type included, therefore, stars of a deeper red colour than those of the third, and Secchi pointed out that this was accompanied by a remarkable change in the spectrum; in fact, of Secchi's four types thus established, the first and second had line spectra and the third and fourth had fluted ones. At that time the important distinction to be drawn between line- and fluted-spectra was not so well recognized as it is at present; and further the relation of spectra to temperature was not so fully considered. Secchi, as a result of laboratory work, however, at once showed an undoubted connection between the absorption flutings in the stars of the fourth type and those seen in the spectrum of carbon under certain conditions; and although this conclusion has been denied, it has since been abundantly confirmed by Vogel and others (see Vogel, *Publicationen*, Potsdam, No. 14, 1884, p. 31).

Relation to Temperature.

At the time that Secchi was thus classifying the stars, the question was taken up also by Zöllner, who in 1865 first threw out the suggestion that the spectra might probably enable us to determine somewhat as to the relative ages of these bodies; and he suggested that the yellow and red light of certain stars were indications of a reduction of temperature (Zöllner, "Photometrische Untersuchungen," p. 243).

In 1868 this subject occupied the attention of Ångström with special reference to the contrasted spectra of lines and flutings. On this he wrote as follows, showing that temperature considerations might help us in the matter of variable stars ("Recherches sur le Spectre solaire," Upsala, 1868):—

"D'après les observations faites par MM. Secchi et Huggins, les raies d'absorption dans les spectres stellaires sont de deux espèces: chez l'une, le spectre est rayé de lignes très-fines, comme le spectre solaire; chez l'autre, les raies constituent des groupes entiers à espaces égaux ou des bandes nuancées. Ces derniers groupes appartiennent vraisemblablement aux corps composés, et je mentionnerai, en particulier, que ceux trouvés dans le spectre de α Orionis ressemblent fort aux bandes lumineuses que donne la spectre de l'oxyde de manganèse. Supposé que ma théorie soit juste, l'apparition de ces bandes doit donc indiquer que la température de l'étoile est devenue assez basse pour que de telles combinaisons chimiques puissent se former et se conserver.

"Entre ces deux limites de température chez les étoiles, limites que l'on peut caractériser par la présence de l'une ou de l'autre espèce des raies d'absorption, on peut s'imaginer aussi un état intermédiaire, dans lequel les gaz

[1] The Bakerian Lecture, delivered at the Royal Society on April 12, by J. Norman Lockyer, F.R.S. Continued from p. 590.

[2] "On the Refractive and Dispersive Power of Different Species of Glass, with an Account of the Lines which cross the Spectrum," Fraunhofer, translated in *Edin. Philosophic Journal*, vol. x., October to April, 1823-24, p. 39.

composés peuvent se former ou se dissocier, suivant les variations de température auxquelles ils sont assujettés par l'action chimique même. Dans cette classe doivent probablement être comprises les étoiles dont l'intensité de lumière varie plus ou moins rapidement, et avec une périodicité plus ou moins constante."

In the year 1873, I referred to this subject in my Bakerian Lecture (*Phil. Trans.* vol. clxiv. pt. 2, 1873, p. 492), in which I attempted to bring to bear some results obtained in solar inquiries upon the question of stellar temperatures.

I quote the following paragraphs :—

I. The absorption of some elementary and compound gases is limited to the most refrangible part of the spectrum when the gases are rare, and creeps gradually into the visible violet part, and finally to the red end of the spectrum, as the pressure is increased.

II. Both the general and selective absorption of the photospheric light are greater (and therefore the temperature of the photosphere of the sun is higher) than has been supposed.

III. The lines of compounds of a metal and iodine, bromine, &c., are observed generally in the red end of the spectrum, and this holds good for absorption in the case of aqueous vapour.

Such spectra, like those of the metalloids, are separated spectroscopically from those of the metallic elements by their columnar or banded structure.

IV. There are, in all probability, no compounds ordinarily present in the sun's reversing layer.

V. When a metallic compound vapour, such as is referred to in III., is dissociated by the spark, the band spectrum dies out, and the elemental lines come in, according to the degree of temperature employed.

Again, although our knowledge of the spectra of stars is lamentably incomplete, I gather the following facts from the work already accomplished with marvellous skill and industry by Secchi, of Rome.

VI. The sun, so far as the spectrum goes, may be regarded as a representative of class (β) intermediate between stars (α) with much simpler spectra of the same kind and stars (γ) with much more complex spectra of a different kind.

VII. Sirius, as a type of α, is (1) the brightest (and therefore hottest ?) star in our northern sky ; (2) the blue end of its spectrum is open,—it is only certainly known to contain hydrogen, the other metallic lines being exceedingly thin, thus indicating a small proportion of metallic vapours ; while (3) *the hydrogen lines in this star are enormously distended*, showing that the chromosphere is largely composed of that element.

There are other bright stars of this class.

VIII. As types of γ the red stars may be quoted, the spectra of which are composed of channelled spaces and bands, and in which naturally the blue end is closed. Hence the reversing layers of these stars probably contain metalloids, or compounds, or both, in great quantity ; and in their spectra not only is hydrogen absent, but the metallic lines are reduced in thickness and intensity, which in the light of V., *ante*, may indicate that the metallic vapours are being *associated*. It is fair to assume that these stars are of a lower temperature than our sun.

In the same year, in a letter to M. Dumas, published in the *Comptes rendus*,[1] I again pointed out that, if we consider merely the scale of temperature, a celestial body with flutings in it would be cooler than one which had lines in its spectrum ; and I also pointed out that, taking the considerable development of the blue end of the spectrum in white stars as contrasted with its feeble exhibition in stars like our sun, we had strong presumptive evidence to the effect that the stars like α Lyræ, with few lines in their spectra, were hotter than those resembling our sun, in which the number of lines was very much more considerable, and I added an inference from this : "plus une étoile est chaude, plus son spectre est simple." This related merely, as I have said before, to the consideration of one line of temperature.

[1] "Il semble que plus une étoile est chaude, plus son spectre est simple, et que les éléments métalliques se font voir dans l'ordre de lines poids anatomiques. Ainsi nous avons :—

"(1) Des étoiles très brillantes, où nous ne voyons que l'hydrogène *en quantité énorme*, et le magnésium.

"(2) Des étoiles plus froides, comme notre soleil, où nous trouvons:—

H + Mg + Na.
H + Mg + Na + Ca . Fe, &c. ;

dans ces étoiles, pas de métalloïdes.

"(3) Des étoiles plus froides encore, dans lesquelles tous les éléments métalliques sont associés, où leurs lignes ne sont plus visibles, et où nous n'avons que les spectres des métalloïdes et des composés.

"(4) Plus une étoile est âgée, plus l'hydrogène libre disparait ; sur la terre, nous ne trouvons plus l'hydrogène en liberté."

Vogel's Classification.

In the year following my paper, the most considerable classification which has been put forward of late years was published by Dr. Vogel (*Astr. Nach.*, No. 2000), who, basing his work on the previous types of Secchi, and taking into account the inference I drew in my letter to Dumas, modified Secchi's types to a certain extent, but always along one line of temperature, the leading idea being, as I gather from many remarks made in Dunér's admirable memoir, to be referred to presently, that the classification is based upon descending temperatures, and that all the stars included in it are supposed at one time or other to *have had* a spectrum similar to that of α Lyræ.[1]

This classification is as follows :—

CLASS I. *Spectra in which the metallic lines are extremely faint or entirely invisible.*—The most refrangible parts, blue and violet, are very vivid. The stars are white.

(*a*) Spectra in which the lines of hydrogen are very strong.

(*b*) Spectra in which the lines of hydrogen are wanting.

(*c*) Spectra in which the lines of hydrogen and D_3 are bright.

CLASS II. *Spectra in which the metallic lines are numerous and very visible.*—The blue and violet are relatively weaker ; in the red part there are sometimes faint bands. The colour of the stars is clear bluish white to deep reddish yellow.

(*a*) Spectra with numerous metallic lines, especially in the yellow and green. The lines of hydrogen are generally strong, but never as strong as in the stars of Class I. In some stars they are invisible, and then faint bands are generally seen in the red formed by very close lines.

(*b*) Spectra in which besides dark lines and isolated bands there are several bright lines.

CLASS III. *Spectra in which besides the metallic lines there are numerous dark bands in all parts of the spectrum, and the blue and violet are remarkably faint.*—The stars are orange or red.

(*a*) The dark bands are fainter towards the red.

(*b*) The bands are very wide, and the principal are fainter towards the violet.

It is pointed out that if this classification be true, there must be links between all the classes given. Now it is perfectly obvious that if this classification includes in its view all the stars, and if there is a line of ascending as well as descending temperatures—that is to say, if some of the stars are increasing their temperatures, while others are diminishing them—the classification must give way.

It is not difficult to see, in the light of my communication to the Society of November 17, that it has given way altogether, and principally on this wise.

The idea which underlies the classification is that a star of Class I. on cooling becomes a star of Class II., and that a star of Class II. has as it were a choice before

[1] "Car selon la théorie il faudra que tôt ou tard toutes les étoiles de la première classe deviennent de la seconde, et celles-ci de la troisième" (Dunér).

it of passing to Class III.*a* or Class III.*b*. Thus under certain conditions its spectrum will take on the appearance of Secchi's third type, Class III.*a* (Vogel); on certain other conditions it will take on the appearance of Secchi's fourth type, Class III.*b* (Vogel). There is now, however, no manner of doubt whatever that Secchi's Class III.*a* represents stars in which the temperature is increasing, and with conditions not unlike those of the nebulæ—that is to say, the meteorites are yet discrete, and that they are on their way to form bodies of Class II. and Class I. by the ultimate vaporization of all their meteoric constituents. There is equally no manner of doubt that the stars included in Class III.*b* have had their day; that their temperature has been running down, until owing to reduction of temperature they are on the verge of invisibility brought about by the enormous absorption of carbon in their atmospheres.

Pechüle was the first to object to Vogel's classification, mainly on the ground that Secchi's types 3 and 4 had been improperly brought together; and my work has shown how very just his objection was,[1] and how clear-sighted was his view as to the true position of stars of Class III.*b*.

II. Proposed New Grouping of all Celestial Bodies according to Temperature.

Having, then, gone over the various classifications of stars according to their spectra, I now proceed to consider the question of the classification of celestial bodies from a more advanced point of view. I pointed out in the year 1886 that the time had arrived when stars with increasing temperatures would require to be fundamentally distinguished from those with decreasing temperatures, but I did not then know that this was so easy to accomplish as it now appears to be (Nature, vol. xxxiv. p. 228); and as I have already stated, when we consider the question of classification at all, it is neither necessary nor desirable that we should limit ourselves to the stars; we must include the nebulæ and comets as well, and the question of variability does not really concern us, because it is as a rule in its extremest form the passage of a body giving one spectrum to a body giving another even if of a different type, owing to sudden changes of temperature.

[1] "M. Vogel a proposé une classification suivant les diverses phases de refroidissement indiquées par les spectres, dans laquelle il fait des types III. et IV. de Secchi deux subdivisions d'une même classe, III.*a* et III.*b*. Mais je trouve certaines difficultés négatives contre cette classification relativement au rôle qu'y joue la III.*b*. En effet, il est admis que le IV. type de Secchi se distingue nettement du III. type, non seulement par la position et la quantité des zones obscures, mais aussi par le fait très-remarquable, que les principales de ces zones sont bien définies et brusquement interrompues du côté du violette dans le III. type du côté du rouge dans le IV. Or, si le IV. type doit représenter une des phases de refroidissement, par lesquelles passent les étoiles, on peut faire deux hypothèses. La première est que le spectre du IV. type soit coordonné au spectre du III. type, de manière qu'il ait des étoiles, qui passent de la phase représentée par le II. type, à la phase représentée par le III. type, et d'autres, qui passent directement du II. type au IV. Mais cette hypothèse est inadmissible. Car on connait de spectres entremédiaires entre le I. et le II. type, et entre le II. et III.; mais on ne connait pas, à ce que je sache, de spectres du II. type tendant au IV. Reste donc l'hypothèse, que la phase de refroidissement, représentée par le spectre du IV. type, soit postérieure à la phase représentée par le III. type, de manière que les spectres des étoiles passent du III. au IV. type. Si ce passage se fait peu à peu, il devrait avoir des spectres entremédiaires entre le III. et le IV. type; mais quoique Secchi par exemple le 17 Jan., 1868, ait déterminé le spectre de l'étoile 273 Schjell., comme semblant entremédiaire entre le III. et le IV. type, il l'a plus tard reconnu du IV. type, et l'existence de spectres du III.-IV. type n'est nullement prouvée. On pourrait objecter que les étoiles du IV. type sont peu nombreuses et en général si petites que leurs spectres sont difficiles à voir, et que par conséquent il pourrait y avoir parmi ces spectres quelques-uns, qui se rapprochassent du III. type. Mais je réponds à cette remarque, que les spectres du III.-IV. type, indiquant une phase moins refroidie, devraient au contraire en général appartenir à des étoiles plus grandes que celles ayant des spectres du IV. type. Si on veut supposer que le passage du III. au IV. type se fasse subitement, ou par une catastrophe, pendant laquelle apparaissent des lignes brillantes, cette supposition même constituerait une différence physique bien plus distincte entre le III. et le IV. type, qu'entre le II. et le III.; et le IV. type représenterait une phase bien distincte, la dernière peut-être avant l'extinction totale. Le rôle physique du IV. type est donc encore si mystérieux, que j'ai cru pouvoir encore me conformer à l'exemple de d'Arrest, en suivant la classification formelle de Secchi."—C. F. Pechüle, "Expédition Danoïse pour l'Observation du Passage de Venus, 1882," p. 25 (Copenhagen, J. H. Schultz, 1883).

In the first classification on these lines, which is certain to be modified as our knowledge gets more exact, it is desirable to keep the groups as small in number as possible; the groups being subsequently broken up into sub-groups, or, as I prefer to call them, species, as the various minute changes in spectra brought about by variations of temperature are better made out.

In my paper of November 17 (Nature, vol. xxxvii. p. 84), I gave a diagram of the "temperature curve," on which is shown the distribution of nebulæ and of stars as divided into classes by Vogel, on the two arms of the curve.

On one arm of this we have those stages in the various heavenly bodies in which in each case the temperature is increasing, while on the other arm we have that other condition in which we get first vaporous combination, and then ultimately the formation of a crust due to the gradual cooling of the mass in dark bodies like, say, the companion to Sirius. At the top we of course have that condition in which the highest temperature must be assumed to exist.

To begin, then, a more general classification with the lowest temperatures, it is known that the nebulæ and comets are distinguished from most stars by the fact that we get evidence of radiation. Absorption has been suspected in the spectra of some nebulæ,[1] and has been observed beyond all doubt in some comets.[2] But there are some stars in which we also get radiation, accompanied by certain absorption phenomena; but there is no difficulty in showing that these bodies are more special on account of their bright lines than on account of their absorption bands. We may therefore form the first group of bodies which are distinguished by the presence of bright lines or flutings in the spectrum.

The presence or absence of carbon will divide this group into two main divisions, which, however, we may neglect in the following very brief sketch which I give in advance of a more detailed treatment.

The first species in this group would contain the nebulæ, in which only the spectrum of the meteoric constituents is observed. In the second species we find the spectrum of hydrogen added.

Another early species would contain those bodies in which the nebula spectrum gets almost masked by a continuous one, such as Comets 1866 and 1867, and the great nebula in Andromeda.

In the second division will be more condensed swarms still, in which, one by one, new lines are added to the spectra, and carbon makes its appearance; while probably the last species in this group would be bodies represented by γ Cassiopeiæ.

The great distinction between the first group and the second would be that evidences of absorption now become prominent, and side by side with the bright flutings of carbon and occasionally the lines of hydrogen we have well-developed fluting absorption.

The second group, therefore, is distinguished from the first by mixed flutings—that is to say, the presence of bright and dark flutings as well as lines in the spectrum.

I give a detailed examination into the species of this group in the next part of this memoir.

[1] "Nebula [No. 117, 51h. 32 M. R.A. 0h. 35m. 5·3s.; N.P.D. 49° 54′ 12″·7. Very, very bright; large, round; pretty suddenly much brighter in the middle].—This small but bright companion of the great nebula in Andromeda presents a spectrum exactly similar to that of 31 M [the great nebula in Andromeda]. The spectrum appears to end abruptly in the orange; and throughout its length is not uniform, but is evidently crossed either by lines of absorption or by bright lines" (Huggins, *Phil. Trans.* vol. cliv. p. 441).

[2] "A dark band was noticed at wave-length 567·9" (Copeland, Comet III., 1881, *Copernicus*, vol. ii. p. 226).

"May 20.—With none of these dispersions could any bright bands, properly so called, be distinguished; but two faint broad *dark* bands, or what gave that impression, crossed the spectrum. . . . A third dark band was suspected near D on the blue side of that line" (Maunder, Comet *a* 1882 (Wells), "Greenwich Spectroscopic Observations, 1882," p. 34).

The dark bands were observed again, and their wave-lengths measured on May 31" (*ibid.* p. 35).

The passage from the second group to the third brings us to those bodies which are increasing their temperature, in which radiation and fluting absorption have given place to line absorption.

At present the observations already accumulated have not been discussed in such a way as to enable us to state very definitely the exact retreat of the absorption, by which I mean the exact order in which the absorption lines fade out from the first members to the last in the group. We know generally that the earlier species will contain the line absorption of those substances of which we get a paramount fluting absorption in the prior group. We also know generally that the absorption of hydrogen will increase while the other diminishes.

The next group, the fourth, brings us to the stage of highest temperature, to stars like α Lyræ; and the division between this group and the prior one must be more or less arbitrary, and cannot at present be defined. One thing, however, is quite clear, that no celestial body without all the ultra-violet lines of hydrogen discovered by Dr. Huggins can claim to belong to it.

We have now arrived at the culminating point of temperature, and now pass to the descending arm of the curve of temperature. The fifth group, therefore, will contain those bodies in which the hydrogen lines begin to decrease in intensity, and other absorptions to take place in consequence of reduction of temperature.

One of the most interesting problems of the future will be to watch what happens in bodies along the descending scale, as compared with what happens to the bodies in Group III. on the ascending one. But it seems fair to assume that physical and chemical combinations will now have an opportunity of taking place, thereby changing the constituents of the atmosphere; that with every decrease of temperature an increase in the absorption lines may be expected, but it will be unlikely that the last species in this group will resemble the first one in Group III.

The next group, the sixth, is Secchi's type IV. and Vogel's Class III.*b*, its distinct characteristics being the absorption flutings of carbon. The species of which it will ultimately be composed are already apparently shadowed forth in the map which accompanies Dunér's volume, and they will evidently be subsequently differentiated by the gradual addition of other absorptions to that of carbon, while at the same time the absorption of carbon gets less and less distinct.

To sum up, then, the classification I propose consists of the following groups:—

GROUP I.—Radiation lines and flutings predominant. Absorption beginning in the last species.
GROUP II.—Mixed radiation and absorption predominant.
GROUP III.—Line absorption predominant, with *increasing* temperature. The various species will be marked by increasing simplicity of spectrum.
GROUP IV.—Simplest line absorption predominant.
GROUP V.—Line absorption predominant, with *decreasing* temperature. The various species will be marked by decreasing complexity of spectrum.
GROUP VI.—Carbon absorption predominant.
GROUP VII.—Extinction of luminosity.

It will be seen from the above grouping that there are several fundamental departures from previous classifications, especially that of Vogel.

The presence of the bright flutings of carbon associated with dark metallic flutings in the second group, and the presence of only absorbing carbon in the sixth, appears to me a matter of fundamental importance, and to entirely invalidate the view that both groups (the equivalents of III.*a* and III.*b* of Vogel) are produced from the same mass of matter on cooling.

This point has already been dwelt upon by Pechüle.

Another point of considerable variation is the separation of stars with small absorption into such widely different groups as the first and fourth, whereas Vogel classifies them together on the ground of the small absorption in the visible part of the spectrum. But that this classification is unsound is demonstrated by the fact that in these stars, such as γ Cassiopeiæ and β Lyræ, we have intense variability. We have bright hydrogen lines instead of inordinately thick dark ones; and on other grounds, which I shall take a subsequent opportunity of enlarging upon, it is clear that the physical conditions of these bodies must be as different as they pretty well can be.

It will be seen also that, with our present knowledge, it is very difficult to separate those stars the grouping of which is determined by line absorption into the Groups III. and V., for the reason that so far, seeing that only one line of temperature, and that a descending one, has been considered, no efforts have been made to establish the necessary criteria. I made this point in the paper to which I have already referred in connection with the provisional curve, and for purposes of completeness I introduce here the chief part of what I wrote on that occasion.

(*To be continued.*)

THE HITTITES, WITH SPECIAL REFERENCE TO VERY RECENT DISCOVERIES.[1]

V.

SOME months ago the Rev. Greville J. Chester brought to this country a quadrangular hæmatite seal found near Tarsus. Though this seal shows, in certain particulars, some analogy with the Yuzgât seal, yet it gives little or no additional aid in the decipherment of the inscriptions. It presents, nevertheless, features of very great interest. Prof. Sayce scarcely goes beyond the merits of the seal when he says that it possesses a "unique and splendid character; nothing like it has ever before been brought to the notice of European scholars."[2] The seal is engraved not only on the base (1), but also on the four sides, while opposite the base the stone was so cut as to serve the purpose of a handle. On four out of the five engraved faces are to be seen two figures—one seated and one standing. These may be supposed to represent men or deities, or possibly, in some cases, ideal personages. At first sight it may seem difficult to discern any general aim or connected purpose in the curious figures depicted. On more attentive examination, however, there is seen to be exhibited a pervading principle of *tri-unity*, especially as exemplified in the triangle and the trident. Moreover, while on three faces of the seal (1, 2, 5) there are figures with the "pig-tail" (an appendage which suggests a connection with the Hittites), it appears tolerably evident that the engraver of the seal intended to represent the personages with this appendage as destitute of the valuable knowledge and power connected with the mysterious three-in-oneness of the triangle and the trident. This is entirely in accordance with the position that the wearers of the pig-tail were still regarded as aliens and intruders when the seal was engraved.

On the base (1), a figure standing or advancing holds in the left hand a trident-like object, which is probably to be understood as a plant; though, like the curious symbols on the Boghaz-Keui bas-relief (*supra*, pp. 513, 514), it must be somewhat idealized. Certainly, it would seem

[1] Based on Lectures delivered by Mr. Thomas Tyler at the British Museum in January 1888. Continued from p. 593.

[2] *Archæological Journal*, December 1887. Prof. Sayce's paper is accompanied by an autotype representation of the seal. I may here mention, also, that impressions of this seal, as also of the Yuzgât seal and the seal of Tarkutimme, may be obtained at a small cost from Mr. A. Ready, of the British Museum.

difficult or impossible to identify it with any known vegetable production. And it would be equally difficult to determine what is the plant held in the hand of the sitting figure wearing the pig-tail,[1] though there seems to be a flower with a long depending and somewhat fibrous root. The two objects apparently are presented in comparison or competition, while that in the hand of the standing figure has the superiority.

On the second face a very curious scene is depicted. Above a kind of altar in the centre is a trident-like object, evidently identical with that already described. The trident-like object is between two symbols of remarkable form, capped with equilateral triangles. On these remarkable symbols, which probably represent life in general, or particularly human life, something more must be said directly. A figure, probably that of a deity, with the head of a hawk or eagle,[2] is pouring out a libation at the foot

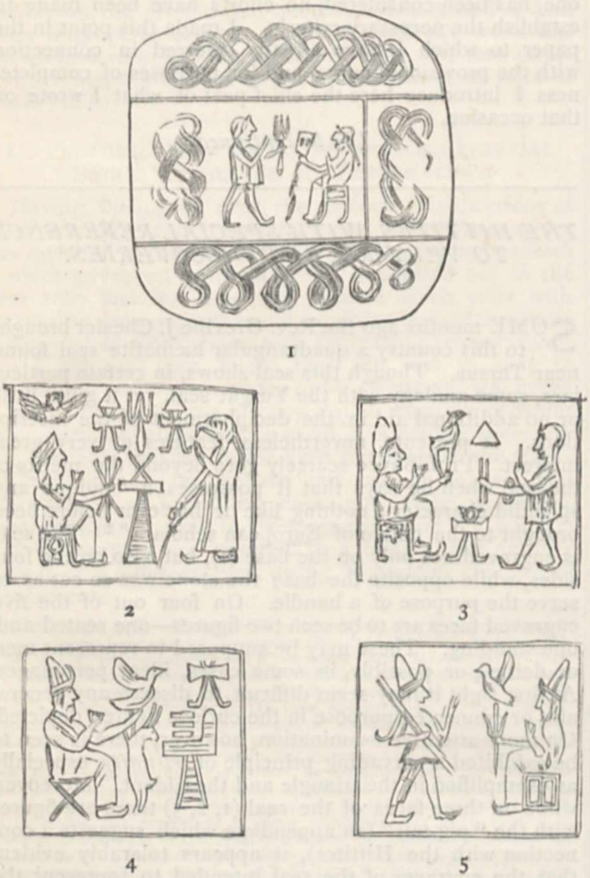


Fig. V.—The Tarsus seal (enlarged).

of the altar, and thus, we may presume, is confessing the superiority of the sacred objects above. On the other side of the altar is, it may be supposed, another deity, having above his head the winged solar disk, and in his left hand a double three-forked thunderbolt, introduced here, it may be supposed, as another emblem of tri-unity.

On the third face there is no personage wearing the pig-tail. Both the seated and the standing figures appear to be occupied with the mystery of the triangle. The engraver of the seal, moreover, as though determined that we should not mistake his meaning, actually represents the seated figure as forming a triangle with one hand. On face (4) the triangle formed by the hand is particularly clear in the impression of the seal; but there can scarcely be a doubt that the intention is the same also on this face (3) as well as on (2) and (5). How the triangle is supposed to be formed by the hand I am unable to say. By comparing the two hands of the seated figure in (3) it becomes evident that the goat standing on the left hand is here introduced as forming a triangle by his position. But still more remarkable and interesting is the personage standing, if considered together with the associated objects. This personage is supporting, apparently by a cord, a figure similar to those spoken of in connection with the second face as probably representing life in general, or more particularly the principle of human life. From the circular head of the figure are projecting what look like ears, but the triangular cap with which the head is covered on the second face is now seen above. The personage supporting the figure has in his left hand one rod held vertically, and in the right two vertical and parallel rods, thus suggesting the triangular number, three, a number regarded in antiquity as especially sacred.

The fourth face presents a single seated figure, making, as said just above, a triangle with the right hand. The left hand holds captive a hare as well as a bird with wings extended. The intention would seem to be to set forth the subjugation of the lower animals through the influence of such supposed occult and mysterious powers as those of the triangle. In front is an altar or table with objects upon it, which, it should be observed, are three in number. Above is a symbol generally identical with those spoken of in connection with faces (2) and (3), but here it is imperfect.

On the last face (5) we have apparently a competition between a pig-tailed figure standing or advancing and another figure seated. The pig-tailed figure holds two parallel rods or spears; and it would certainly appear that he is to be regarded as unequal in power to the seated figure, who is making a triangle with the left hand, while in the right hand is that symbol of tri-unity, the trident, now of more usual form, and differing considerably from the trident-like objects of (1) and (2). On the middle point of the trident is a bird with wings expanded. In this last respect the intention would seem to be somewhat similar to that expressed by the hare and bird held captive on face (4).

The Tarsus seal is probably less ancient than the Yuzgât seal; but there are nevertheless important points of resemblance, which may be reasonably taken as indicating a relationship more or less close. On both seals are to be seen the triangle and the trident, though on the Tarsus seal the form of the latter has become greatly changed. Both seals, also, have the winged solar disk. The wearing a horn in front of the head is another mark of resemblance; and the figures on both seals have the turned-up toes of the so-called "Hittite boots." The eagle-headed figure making the libation has a good deal of similarity to what, as depicted on the Yuzgât seal, I regard as a woman closely veiled, with some object, probably a baby, suspended from her arm (*supra*, p. 560). Notwithstanding any superficial resemblance, however, the objects delineated are certainly very different. The explanation probably is, that the respective engravers had in view a common typical form, which was in each case modified as the particular purpose required. A similar remark may be made with respect to the table or altar on (4), and the object before the king on the Yuzgât seal.

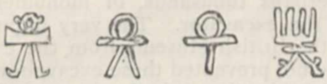
Whether the Tarsus seal will be found of importance with regard to the history of geometry, it would be difficult to say. This may to some extent depend on the date

[1] Prof. Sayce has rightly recognized the presence of the "pig-tail," but when he says that this appendage "characterizes Hittite female figures" (*op. cit.* p. 348), I fail to see any adequate grounds for the assertion. This, I should say, is not the mode of wearing the hair seen on the Boghaz-Keui bas-relief; and I am not acquainted with other evidence which would in any way justify the statement.

[2] The form of this deity suggests a possible relation with the eagle-headed deity on the Assyrian monuments, concerning which Assyriologists have been hitherto unable to give any adequate explanation. Perhaps some fresh light may be eventually derived from the "pig-tail" here appended.

to which the seal is to be referred. But, whatever may be the case with respect to the general history of geometry, certainly there are indications of something very like Pythagoreanism, such as we should by no means have expected to find on a Hittite or Asiatic monument. Still, however unexpected these indications may be, the scientific spirit requires that we should be loyal to facts. Among such indications may perhaps be placed the mysterious powers or properties apparently associated with vegetable forms on the Tarsus seal, as also on the Boghaz-Keui sculpture. But still greater importance and interest attach to the evidence of the seal as to the attribution of occult significance to number and to geometrical form. By the vertical rods of face (3) we are reminded of the Pythagorean doctrine concerning duality and unity, the even and the odd. (Plutarch, *De Is.* 48.) Moreover, we can scarcely mistake the sinister character of duality when we observe that the two parallel rods are carried on face (5) by the pig-tailed figure. Very probably the indications on the seal point to one of the sources whence were derived the doctrines attributed to Pythagoras. And such a view accords very well with the ancient tradition concerning the travels of Pythagoras, and the composite nature of Pythagoreanism.

But some additional consideration requires to be given to the figure on the Tarsus seal (faces 2, 3, 4), which I have spoken of as a symbol of life. In investigating the significance of this figure the most convenient method may be to compare it with the symbol most nearly resembling it which can be found elsewhere. This is to be seen on the coinage of Cyprus (Fig. W, 2). Here we have



1 2 3 4

FIG. W.—1, Symbol on Tarsus seal; 2, symbol on Cypriote coinage 3, *crux ansata*; 4, symbol on Indo-Scythian coin.

the rounded head (though without the projections on the symbol of the Tarsus seal), the horizontal stroke or body, and the divergent legs. True, on the seal there are slight projections at the ends of the horizontal piece, and at the ends of the divergent legs there are the "Hittite boots"; but in this last particular the symbol on the seal resembles the mandrake at Boghaz-Keui (*supra*, p. 514), the ends of the root being similarly turned up and metamorphosed.[1] As to the meaning of the symbol on the Cypriote coinage, we can make a reasonable inference from the fact that it seems to be introduced as an alternative symbol in place of the *crux ansata*, or symbol of life, which, indeed, is quite common on Cypriote coins.[2] The *crux ansata* was possibly derived from Egypt, but still it may very well be regarded as giving an indication of the meaning of the other symbol. If, however, the divergent legs of (2) are supposed to collapse, we have at once a *crux ansata* (3). The evidence so far would go towards the conclusion that the symbol on the Tarsus seal is a symbol of life. But by tracing the Cypriote symbol to its probable origin the evidence may be greatly strengthened.

The coins on which the Cypriote symbol just alluded to occurs are Phœnician. Now there occurs on Phœnician, and especially on Carthaginian, monuments a symbol by which scholars have been much puzzled. It consists of a triangle, normally, as it would seem, equilateral, though varying at times a good deal from this form. At the vertex of the triangle is a horizontal stroke or bar, with projections at the ends, which may be taken for arms, or hands held up; and these also are found to present variations. Above is a head of circular form. This frequently occurring symbol,[1] which may be seen to the reader's left in Fig. X, some scholars have taken for a representation of a man or woman praying and holding up his or her hands. But M. Renan justly observes that the position in which the symbol is found on the monuments is not compatible with such an opinion; and in the figure it evidently appears as

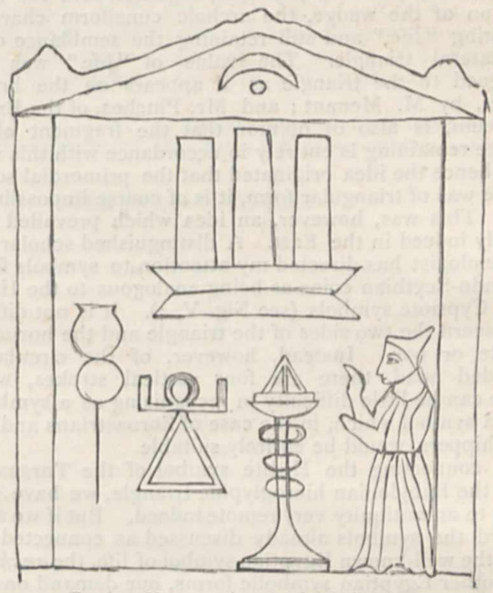
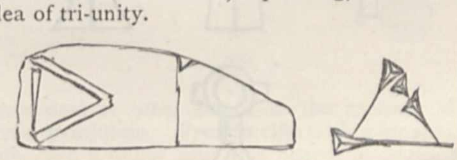


FIG. X.—Upper portion of stele of Lilybæum.

an object of worship. Regarded as denoting life, or as a sort of generalization of deity as the giver of life, its position on the stele becomes intelligible. It corresponds in form with the Cypriote symbol, except that the latter has lost the base of the triangle and the projections at the end of the horizontal piece, but indications of these being retained are clearly to be seen on the Tarsus symbol. M. Renan could make nothing of the triple object above the altar in Fig. X.[2] But when we look at the trident-like object of worship above the altar on face (2) of the Tarsus seal, the problem receives a good deal of light; and we recognize in the mysterious tripartite object of the stele a modification of the trident, expressing, like the triangle, the idea of tri-unity.



1 2

FIG. Y.—1, Portion of broken tablet in the British Museum; 2, archaic cuneiform character, *din*, "life."

With respect to the loss of the base of the triangle in the Cypriote symbol, and the import of this and other symbols before mentioned, we have evidence on a unique tablet in the British Museum. Though it is unfortunately broken, its testimony is still very important. The tablet

[1] The triangular cap of the symbol on face (2) shows a connection between the symbol and the equilateral triangle. But what may be exactly the difference in the significance of the symbol when capped with the triangle and when destitute of this covering it is scarcely possible to say, unless the added triangle is supposed to give power and vitality.

[2] See De Vogüé, "Mélanges d'Archéologie Orientale," plate xi., Figs. 13, 16, 17, 18.

[1] M. Renan observes of this symbol: "Præcipua inter figuras religiosas est imago quâ nihil apud Phœnicas et Pœnos frequentius" ("Corp. inscr. sém.," vol. i. p. 281).

[2] He observes: "Supra figura cernitur tripartita, tribus cippis imparibus constans, cum basi duplici, quæ quid sibi velit non apparet" (*op. cit.* vol. i. p. 179). Fig. X. is a little reduced from the figure in the "Corpus."

gave the ancient hieroglyphic or hieratic forms of some cuneiform characters, with their values. Among these is a triangle the sides of which are represented by doubled lines carefully finished off, while the base, which is to a certain extent dissevered, is represented only by a single line or wedge. We thus see a tendency already to that dropping of the base exemplified in the Cypriote symbol. But is the meaning the same? The cuneiform character giving the value is unfortunately gone, except a small portion of a single wedge, which alone would yield but slender grounds for determining the import of the triangle. We are able, however, to take, together with the small portion of the wedge, the archaic cuneiform character denoting "life," and still retaining the semblance of an equilateral triangle. The value of "life" was that assigned to the triangle as it appears on the broken tablet, by M. Menant; and Mr. Pinches, of the British Museum, is also of opinion that the fragment of the wedge remaining is entirely in accordance with this view.

Whence the idea originated that the primordial source of life was of triangular form, it is of course impossible to say. This was, however, an idea which prevailed very widely indeed in the East. A distinguished scholar and archæologist has directed my attention to symbols found on Indo-Scythian coins as being analogous to the Hittite and Cypriote symbols (see Fig. V, 4). It is not difficult to discern the two sides of the triangle and the horizontal stroke or bar. Instead, however, of the circular or rounded head, there are four vertical strokes, which there can be little difficulty in recognizing as a symbol of fire, a symbol which, in the case of Zoroastrians and fire-worshippers, would be entirely suitable.

In connecting the Hittite symbol of the Tarsus seal with the Babylonian hieroglyphic triangle, we have gone back to an antiquity very remote indeed. But if we are to regard the symbols already discussed as connected also with the well-known Egyptian symbol of life, the *ankh*, and with other Egyptian symbolic forms, our demand on time must probably be much greater. That the Egyptian talismans (Fig. Z, 2, 3, 4) might have been evolved from

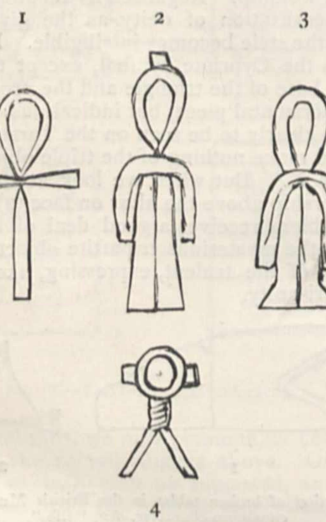


FIG. Z.—1, *Ankh*, Egyptian symbol of life, from coffin of Men-ka-ra, in the British Museum; 2, 3, 4, Egyptian talismans in the British Museum.

a form identical with, or resembling, the headed triangle of the Phœnician monuments, it requires no great stretch of imaginative power to discern.[1] But with regard to the *ankh* (1), so often seen in the hands of deities, though the points of resemblance are tolerably obvious,[1] yet it may seem difficult to understand how the triangle could have assumed the form of the vertical bar. True, the bar is pointed at the apex; and elsewhere on the Egyptian monuments an acute-angled triangle in the corresponding position is sufficiently common. But it is remarkable that this latter form is not seen on a monument so very ancient as the coffin of the king Men-ka-ra. Still, on the whole, it can scarcely be regarded as other than probable that the *ankh*, like the other Egyptian forms depicted, must be referred ultimately to the headed triangle. But, if this view is just, and the triangle had collapsed, as shown in the figure, when the coffin of Men-ka-ra was constructed, the period of man's existence on the earth in a condition of somewhat advanced civilization must be of exceedingly protracted duration.

As to the age of the greater Hittite monuments, it is impossible to speak. To argue that the Hittite hieroglyphs could not have remained long in use by the side of either the cuneiform syllabary or the Phœnician alphabet would be somewhat perilous. A better argument for their great antiquity is furnished by the total absence, so far as can be seen, of any indication of horses or chariots. Yet, in the wars with the Egyptians some fifteen or sixteen centuries before Christ, the Hittites appear well equipped with this kind of forces, in a state of organization from which lengthened usage may be reasonably inferred.

What has been said may suffice to show the extremely great interest of the questions suggested by the Hittite monuments. Unfortunately the material for investigation is at present but scanty, though there are probably hundreds, perhaps thousands, of monuments awaiting the spade of the excavator. The very important results obtained by the British Museum from the excavations at Jerablûs have not prevented these excavations from being for a considerable time wholly suspended. That this should be the case is certainly matter for regret; for I hope that I have at least succeeded in showing that the idea that the solution of the Hittite problem is hopeless is one which cannot be reasonably entertained.

[1] The distinguished Egyptologist, Mr. Le Page Renouf, now Keeper of Oriental Antiquities at the British Museum, tells me that, while (2) and (3) may not be earlier than the eighteenth dynasty, (4) is of very great antiquity, occurring in the name of Hor-em-sa-f, one of the Pyramid kings.

[1] The connection with, or analogy between, the Tarsus and Cypriote symbols and the *ankh* was suggested by Mr. Pinches, and subsequently, with respect to the Tarsus symbol, on different grounds, by Prof. Sayce.

CLASS EXPERIMENTS.

THE following is a brief account of some experiments shown to the students of the Natural Philosophy Class in the University of Glasgow during the present Session. It is communicated to NATURE with the permission of Sir W. Thomson.

I. (1) Suspend a heavy ball by a long wire, as shown in Fig. 1. To the middle of the ball attach a worsted thread, A D. Pull the thread in the direction of the arrow-head, with a pull that will not break it, and let the pull be finished before the ball is sensibly displaced. Observe the greatest subsequent displacement of the ball.

(2) Bring the ball to rest. Pull it now with a pull sufficient to break the thread. Note that the displacement is smaller than in case (1).

(3) Bring the ball to rest once more. Give a very sudden pull to the thread: it breaks, and the displacement of the ball is hardly perceptible.

In each of the three cases the momentum is equal to $\int F dt$ for the whole duration of the pull. The pull in case (1) is smaller than the pull in cases (2) and (3), but the duration of the pull is greater in a greater ratio; hence the momentum communicated, being the time integral of the pull, is the greatest for case (1). Although the pull in case (2) is equal to the pull in case (3), still its duration is so exceedingly small in case (3) that the momentum communicated is very small.

II. Support a cylinder with a fly-wheel, as shown in Fig. 2. E E are two pieces of wood, both screwed at the

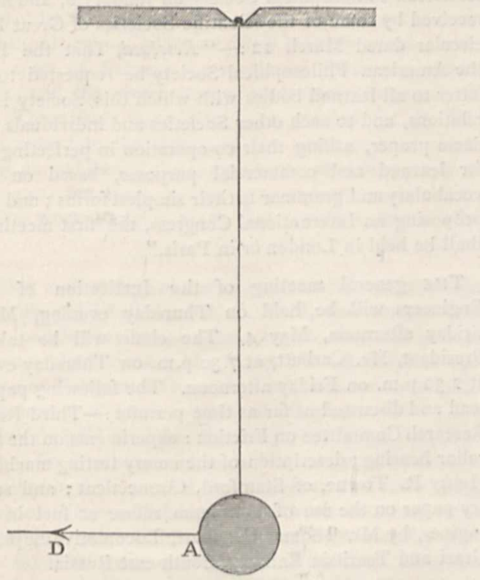


FIG. 1.

top to another piece of wood, L, of convenient thickness. Each has a slot cut along its centre, in which fits a ball, F, to which is attached a stiff wire, a string, and a weight, as shown in the figure. H is an india-rubber band, which presses E E together with a pressure at least sufficient to

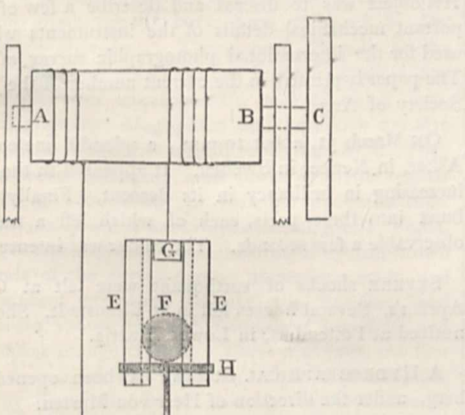


FIG. 2.

cause the ball F not to slip when the weight M is hung on to its string. Another string is wound round the end A of the cylinder, and a weight attached to it so as to balance the weight of the two pieces of wood, E E. The fly-wheel has a friction-brake upon it, and if the retarding force of the brake be constant, the angular displacement of the fly-wheel is proportional to the square of the momentum communicated.

(1) Lift the weight M a distance of about half an inch, and let it fall. The cylinder goes round through a certain angle, and the ball F is not pulled out of its slot.

(2) Lift the weight M through 2 or 3 inches, and let it fall. The ball F is pulled out of its slot; the cylinder goes round, but through a smaller angle than in case (1).

(3) Let the weight M fall through a height of 4 or 5 feet. The ball F is pulled out of its slot, and the angular displacement of the cylinder is barely perceptible.

The same explanations are applicable to the results of II. as were made concerning the results of I., provided couple be substituted for force, and moment of inertia for mass.

III. The following, though somewhat inconvenient as a class experiment, illustrates the same subject. Fix up

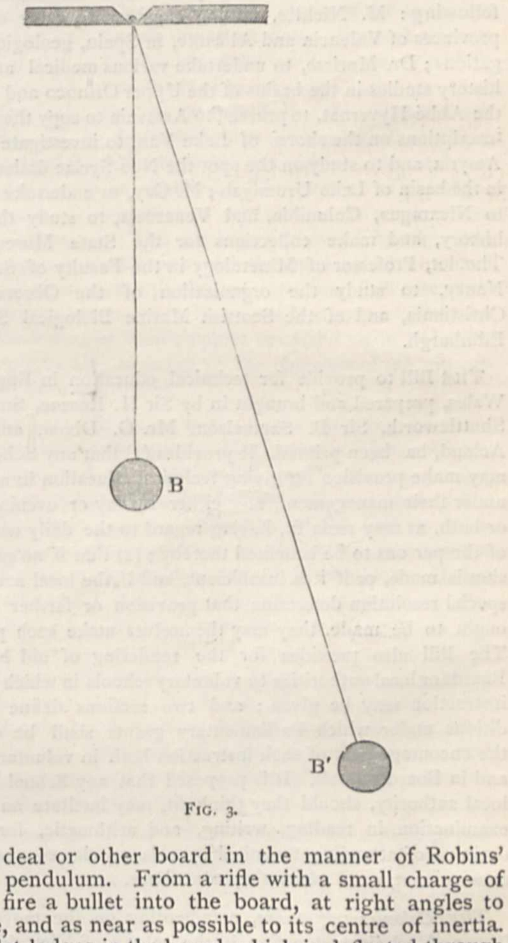


FIG. 3.

a plain deal or other board in the manner of Robins' ballistic pendulum. From a rifle with a small charge of powder, fire a bullet into the board, at right angles to its plane, and as near as possible to its centre of inertia. The bullet lodges in the board, which is deflected through a large angle. Increase the charge of powder, so that the bullet pierces the board. The deflection of the board is now smaller. Put the maximum charge of powder in the rifle, and the deflection of the board on firing the bullet into it is exceedingly small.

IV. Suspend a light ivory or other ball by a long india-rubber thread several feet long, as shown in Fig. 3. Pull the ball into the position A B', and let it go. Looking at it as seen in the figure, it first begins to describe a curve against the hands of a watch. After two or three periods it begins to go round in a direction with the hands of a watch.

Bring the ball to the position B′ again, and project it at right angles, or at any angle, to the plane B A B The ball now illustrates three-dimensional motion. The period is slow, and the experiments are very interesting and instructive. MAGNUS MACLEAN.

NOTES.

THE bi-centenary of the publication of Newton's "Principia" was celebrated on Thursday last at Trinity College, Cambridge. A long and admirable address was read by Dr. Glaisher to a distinguished audience which had been invited to Cambridge by the Master and Fellows of the College. At a numerously attended dinner in Hall in the evening, speeches were made by the Master, the President of the Royal Society, the Astronomers-Royal for England and Ireland, and other distinguished guests.

AMONGST the missions just approved by the Special Commission of the French Ministry of Public Instruction are the following: M. Nicklès, mining engineer, to carry out in the provinces of Valencia and Alicante, in Spain, geological investigations; Dr. Morisse, to undertake various medical and natural history studies in the basins of the Upper Orinoco and Amazon; the Abbé Hyvernat, to proceed to Armenia to copy the cuneiform inscriptions on the shores of Lake Van, to investigate the art of Assyria, and to study on the spot the Neo-Syriac dialects spoken in the basin of Lake Urumiyah; M. Gay, to undertake a mission to Nicaragua, Columbia, and Venezuela, to study the natural history, and make collections for the State Museums; M. Thoulet, Professor of Mineralogy in the Faculty of Sciences at Nancy, to study the organization of the Observatory of Christiania, and of the Scottish Marine Biological Station at Edinburgh.

THE Bill to provide for technical education in England and Wales, prepared and brought in by Sir H. Roscoe, Sir U. Kay-Shuttleworth, Sir B. Samuelson, Mr. G. Dixon, and Mr. A. Acland, has been printed. It provides (1) that any School Board may make provision for giving technical education in any school under their management, and either by day or evening classes, or both, as may seem fit, having regard to the daily occupations of the persons to be benefited thereby; (2) that if no such provision is made, or if it is insufficient, and if the local authority by special resolution determine that provision or further provision ought to be made, they may themselves make such provision. The Bill also provides for the rendering of aid by School Boards or local authorities to voluntary schools in which technical instruction may be given; and two sections define the conditions under which Parliamentary grants shall be made for the encouragement of such instruction both in voluntary schools and in Board schools. It is proposed that any School Board or local authority, should they think fit, may institute an entrance examination in reading, writing, and arithmetic, for persons desirous of attending technical schools or classes under their management, or to which they contribute.

THE *Colonies and India*, commenting on the movement in favour of technical education in the colony of Victoria, says it will not be the fault of the Victorian Government if technical education is neglected, as there is a feeling in the Cabinet that if the country is to progress the rising generation should have the advantage of technical teaching. The Minister of Public Instruction has issued a minute on the policy of founding a Victorian Technical University, which is a digest of some of the evidence given before our own Royal Commission on Technical Instruction. Mr. Pearson estimates the initial expenditure involved in the foundation of a separate technical University at from £500,000 to a million, besides a yearly endowment of at least £30,000. The latter sum appears out of proportion to the average endowments of such institutions in Europe and America. It is not doubted that the money required will be freely voted.

THE following resolution was passed at a meeting of the American Philosophical Society on January 6, and has just been received by some of the scientific Societies of Great Britain in a circular dated March 12:—"*Resolved*, That the President of the American Philosophical Society be requested to address a letter to all learned bodies with which this Society is in official relations, and to such other Societies and individuals as he may deem proper, asking their co-operation in perfecting a language for learned and commercial purposes, based on the Aryan vocabulary and grammar in their simplest forms; and to that end proposing an International Congress, the first meeting of which shall be held in London or in Paris."

THE general meeting of the Institution of Mechanical Engineers will be held on Thursday evening, May 3, and Friday afternoon, May 4. The chair will be taken by the President, Mr. Carbutt, at 7.30 p.m. on Thursday evening, and at 2.30 p.m. on Friday afternoon. The following papers will be read and discussed as far as time permits:—Third Report of the Research Committee on Friction: experiments on the friction of a collar bearing; description of the emery testing machine, by Mr. Henry R. Towne, of Stamford, Connecticut; and supplementary paper on the use of petroleum refuse as fuel in locomotive engines, by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-east Russia.

SURGEON-MAJOR F. S. B. FRANÇOIS DE CHAUMONT, F.R.S., Professor of Military Hygiene at the Army Medical School, Netley, died at his residence at Woolston, near Southampton, on the 18th inst. He was fifty-five years of age.

AT the meeting of the Society of Arts on the 18th inst., Sir Howard Grubb read a paper on telescopes for stellar photography. His object was to discuss and describe a few of the more important mechanical details of the instruments which are to be used for the international photographic survey of the heavens. The paper is printed in the current number of the Journal of the Society of Arts.

ON March 31, about 10 p.m., a splendid meteor was seen at Asker, in Nerice, in Sweden. It appeared in the southern sky, increasing in brilliancy in its descent. Finally it seemed to burst into three parts, each of which left a trail in the sky observable a few seconds. The colour was intense bluish-white.

SEVERE shocks of earthquake were felt at Oldenburg on April 12. Several houses fell in at Eisenstadt. Shocks were also noticed at Pottendorf, in Lower Austria.

A HYDROGRAPHICAL BUREAU has been opened in Würtemberg, under the direction of Herr von Marten.

WE are glad to hear that a regular meteorological organization is to be established in Spain. The Director, appointed by "competitive examination," is Señor Augusto Arcimis, formerly of the Institution Libre de Ensenanza, Madrid. M. Arcimis has long been known as a meteorologist.

MM. MOHN AND HILDEBRANDSSON have published an important discussion on the "Thunderstorms of Scandinavia" (Upsal, 1888, 55 pp. and 12 plates). The first network of thunderstorm stations was established in France by Leverrier in 1865, and his plan has been adopted in most other countries, almost without change. Norway followed next, in 1867, and Sweden in 1871. The storms are divided into two classes: (1) heat thunderstorms, which occur generally in summer, and mostly originate in the central and eastern parts of the Scandinavian peninsula 2) cyclonic thunderstorms, which generally occur in winter, on the western coasts, and accompany a barometric depression coming from the Atlantic. An attempt is made at fixing the heights of thunderstorm clouds, but these vary very much with different times and localities; it seems proved, however, that the movements of the cirrus clouds are in no way affected by the storms. The summer storms occur most frequently in the afternoon, and most rarely between 2 and 4 a.m. But on the coast of Norway the maximum frequency occurs about 8 p.m., and the winter storms occur more frequently in the night. These facts have also been pointed out by Dr. Buchan with regard to the storms of the north-west of Scotland. In the annual period the storms occur most frequently in July and August, but there is also a secondary maximum in January. The work contains much that would repay careful study.

THE monthly meteorological notes and rainfall statistics for South Australia, published by Mr. C. Todd, the Government Astronomer, contain very useful climatological data and notices of miscellaneous phenomena. Mr. Todd has taken advantage of his position as Postmaster-General to establish meteorological or rainfall stations at a great number of telegraph offices; the number of reports published for February 1887 is 298, together with the means for all stations having at least seven years' record. The observations in their present form seem to date from 1883, when 235 records were published, but the work commenced as as far back as 1857, since which time it has been steadily pursued. For Adelaide itself, the records of Sir G. S. Kingston extend back as far as 1839, and these observations have been used by Mr. Todd in his excellent article on the climate of the colony in the "Hand-book of South Australia." It is stated in this work that local features are apparently insufficient to explain the large differences in the yearly averages of the rainfall; Mr. Todd's continued exertions must tend to elucidate this subject.

A NEW series of isomorphous double chlorides of the metals of the iron and alkali groups have been prepared by Dr. Neumann (*Liebig's Annalen*). The general formula of the system is $4RCl \,.\, M_2Cl_6 + 2H_2O$, where R may represent any member of the group of alkali metals, and M either iron, chromium, or aluminium. Magnesium and beryllium are also included in the series, $2MgCl_2$ or $2BeCl_2$ replacing 4RCl. They all crystallize in forms belonging most probably to the regular system, generally in octahedrons or rhombic dodecahedrons. The iron salts especially are remarkably beautiful, $4KCl \,.\, Fe_2Cl_6 + 2H_2O$ forming octahedrons and dodecahedrons of reddish-brown tint, while crystals of the corresponding ammonium compound possess a magnificent garnet-red colour; the rubidium and magnesium salts are yellow, and the chloride of beryllium and iron separates in fine orange crystals. These iron salts, the first two of which have been known some time, are prepared comparatively readily by dissolving ferric chloride in concentrated hydrochloric acid, adding the necessary quantity of the alkaline chloride, and crystallizing. But Dr. Neumann, in attempting to complete the series, found considerable difficulty in preparing the corresponding chromium and aluminium salts. He eventually succeeded completely, in the case of chromium, by dissolving the chromium chloride in warm 96 per cent. alcohol, adding a proportionately small quantity of the other chloride and passing a rapid stream of hydrochloric acid gas, the whole being gently boiled for some time, using a reflux condenser. It was found that the 4 per cent. of water, together with that liberated during the formation of ethyl chloride, was just sufficient to supply the water of crystallization, hence on cooling the double salt crystallized out in microscopic crystals resembling in shape those of their ferric brethren. These chromium salts are of various shades of violet, are deliquescent like all other members of the series, and are likewise decomposed by water. The only aluminic member of the series yet prepared by Dr. Neumann is the potassium compound $4KCl \,.\, Al_2Cl_6 + 2H_2O$, which, however, is one of the finest of the whole class; it crystallizes in splendid octahedrons, resembling large diamonds and refracting light with similar brilliancy. Crystals will ever remain among the choicest fruits of the chemist's labour, and form an inexhaustible source of pleasure to lovers of the beautiful. The new isomorphous group is of great theoretical interest, and will take its rank with the well-known alums and the double sulphates of the ferrous-ammonium type.

A MOST interesting account of the work in mound-exploration carried on by the United States Bureau of Ethnology, has been issued by the Smithsonian Institution. The writer is Mr. Cyrus Thomas. It seems that over two thousand mounds have been explored, including almost every known type as to form, from the low, diminutive, circular burial tumulus of the north, to the huge, truncated, earthen pyramid of the south, the embankment, the effigy, the stone cairn, house site, &c. Every hitherto known variety as to construction, as well as a number decidedly different in details, has been examined. Some of the latter are very interesting and furnish important data. Particular attention has been paid to this branch of the work, because the mode of construction and the methods of burial in the ordinary conical tumuli furnish valuable data in regard to the customs of the builders, and aid in determining the archæological districts. Many ancient graves and cemeteries and several *caches* and cave deposits have also been explored. The number of specimens obtained by the division since its organization is not less than thirty-eight thousand. The specimens procured by the field assistants in person constitute by far the most valuable portion of the collection, since the particulars regarding their discovery and surroundings are known. Not a single stone or tablet with anything like letters or hieroglyphics inscribed on it, by which linguists might be able to judge of the language of the mound-builders, has been discovered.

A SECOND Laura Bridgman is at present attracting the attention of American psychologists. Her name is Helen Keller. Although blind and deaf, she makes rapid progress in her studies. *Science* (April 6) gives her portrait and that of her teacher, Miss Annie Sullivan, a graduate of the Perkins Institute at Boston, and also reproduces in *facsimile* a letter written by Helen Keller to A. Graham Bell, of Washington. It was only in March 1887 that Miss Sullivan was engaged to give the first instruction to her pupil, who was then six years old. In a month the little girl learned to spell about 400 words, and in less than three months could write a letter, unaided by anyone. In six weeks she mastered the Braillé (French) system, which is a cipher for the blind, enabling them to read what they have written. She has also mastered addition, multiplication, and subtraction, and received lessons in geography. She is trained solely through the sense of touch.

THE new number of the "Year-Book of the Scientific and Learned Societies of Great Britain and Ireland" (Griffin and Co.) has just been published. This is the fifth annual issue. It comprises lists of papers read during 1887 before Societies engaged in all departments of research, with the names of their authors. There is also an appendix, presenting a list of the leading scientific Societies throughout the world. The work is a useful one, but it ought to have been more thoroughly revised. On the very first page, in the list of the members of the Council of the Royal Society, two names are wrongly given: Sir A. (instead of W.) Bowman, and R. (instead of W.) T. Thiselton Dyer.

A PAPER entitled "Additional Records of Scottish Plants for the Year 1887," by Mr. Arthur Bennett, has been sent to us. It consists of a list of the new county botanical records which came under Mr. Bennett's notice during 1887, and forms a continuation of the lists which appeared in the *Scottish Naturalist* for 1886 and 1887. Mr. Bennett says that the results during the year 1887 were probably richer than in any former year, not only in the large number of comital records, but in the new species added to the Scottish flora.

WE have received several numbers of the *Annales de la Faculté des Sciences de Toulouse* (Paris: Gauthiers-Villars). This new publication (which is well printed on good paper, with wide margins) consists chiefly of memoirs relating to physics, chemistry, and mathematics pure and applied. It contains also articles on questions of general scientific interest. To papers of the latter class the authors append lists of books on the questions discussed.

ACCORDING to a paper in the *Board of Trade Journal* for April, the production of attar of roses constitutes one of the most important branches of native industry in Bulgaria. The valley of Kezanlyk, known as the Vale of Roses, is the centre of this production, which extends as far as Carlovo, and the villages which lie sheltered from the north wind by the vast chain of the Great Balkans. In 1885, and no later statistics have been published, the manufacture of attar of roses in the district indicated amounted to a value of 1,100,000 francs. The prosperous condition of the valley of Kezanlyk has led other districts of Bulgaria to develop the same industry, and particularly the inhabitants of Strema, and of Toundja, at the foot of Mount Rhodope. It is not yet certain that the attar from these new countries will equal in quality the famous product of Kezanlyk. The Government, however, is anxious to encourage this movement, and the Department of the Interior has lately authorized the purchase of a certain quantity of attar prepared at Strema and at Toundja. Specimens of each are to be sent for examination at the laboratory of the University of Moscow, and the result is to be published.

FROM an official report just published it appears that in 1886 there were killed in Norway 114 bears, 37 wolves, 5618 foxes, 950 eagles, 5100 hawks, and 108 other animals of prey. The number of bears was slightly below that of 1885, but above the numbers of previous years, whilst the number of wolves was twice that of 1885. The number of foxes, on the other hand, was only half that of the previous year, whilst those of eagles and hawks were about the same.

IN last week's NATURE (p. 581), near the middle of the second column, for "Ekholm *of* Hagström," read "Ekholm *and* Hagström."

THE additions to the Zoological Society's Gardens during the past week include a Common Marmoset (*Hapale jacchus*) from South-East Brazil, presented by Mrs. Leighton; a Striped Hyæna (*Hyæna striata*) from Morocco, presented by Mr. Herbert E. White; an Indian Wolf (*Canis pallipes* ♂), two —— Foxes (*Canis* ——), a —— Hawk Eagle (*Spizaetus* ——) from India, presented by Colonel Alex. A. A. Kinloch, C.M.Z.S.; two Rock-hopper Penguins (*Eudyptes chrysocome*) from Auckland, New Zealand, presented by Captain Sutcliff, R.M.S.S. *Aorangi*; a Gannet (*Sula bassana*), British, presented by Miss Serrell; three Common Swans (*Cygnus olor*), British, purchased; a Chinchilla (*Chinchilla lanigera*), a Barbary Wild Sheep (*Ovis tragelaphus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

PHOTOGRAPHY IN THE DETERMINATION OF THE MOTIONS OF STARS IN THE LINE OF SIGHT.—Of the many developments of spectroscopy, one of the most interesting is that first made a practical branch of observation by the skill and patience of Dr. Huggins, viz. the determination of the motions of stars in the direction of the visual ray by measures of the displacement of the more prominent lines in their spectra. The research has, however, always been beset with many practical difficulties, one of the most serious being the manner in which the stellar lines seem to elude the sight when the air is disturbed. This hindrance has been especially felt at Greenwich, where this kind of work has been adopted as part of the ordinary routine, and where, in consequence, it has not been possible, as would be the case in a private observatory, to confine observation to nights of faultless definition. Many of the observations have, therefore, been exceedingly rough, or even discordant. Prof. H. C. Vogel, who had made some successful measures of the displacements of lines in three or four of our brightest stars soon after Huggins's first observations, has recently turned his attention to photography as a means of overcoming this difficulty, and his first results, given in a paper read before the Royal Prussian Academy on March 15, are very promising. Prof. Vogel finds that the atmospheric tremors, so wearisome to the eye, exercise no influence upon the photograph, which possesses the additional advantage of being free from all bias or predisposition. Dr. Scheiner, who has been carrying out these experiments, has examined seven spectra, viz. those of Sirius, Procyon, Castor, Arcturus, Aldebaran, Pollux, and Rigel. Of these, Sirius showed a slight displacement to the red, Procyon a decided displacement, and Rigel very large in the same direction, whilst Arcturus showed a considerable displacement towards the violet. The observations were made on the third line of hydrogen, Hγ, a train of two prisms of high dispersion being used.

THE TOTAL LUNAR ECLIPSE OF JANUARY 28.—Dr. E. Lindemann sends the following list of the number of occultations observed at different Observatories during this eclipse, in addition to the lists given already: Albany (U.S.), 7; Christiania, 28; Milan, 23; Bonn, 7; Durban (Natal), 17; Oxford (Radcliffe), 9; Bruxelles, 14; Liège, 5; Palermo, 8; Cape of Good Hope, 21; Madras, 10. The weather was cloudy at Warsaw.

NEW MINOR PLANETS.—Herr Palisa discovered a new minor planet, No. 274, on April 3, and another, No. 275, on April 13. The latter is his sixty-third discovery. No. 269 has received the name of Justitia.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 APRIL 29—MAY 5.

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

At Greenwich on April 29

Sun rises, 4h. 36m.; souths, 11h. 57m. 10·3s.; sets, 19h. 18m.: right asc. on meridian, 2h. 28·7m.; decl. 14° 41′ N. Sidereal Time at Sunset, 9h. 51m.

Moon (at Last Quarter May 3, 0h.) rises, 22h. 21m.*; souths, 2h. 46m.; sets, 7h. 6m.: right asc. on meridian, 17h. 15·7m.; decl. 19° 30′ S.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	4 23 ...	11 11 ...	17 59 ...	1 42·0 ...	8 45 N.
Venus.....	4 8 ...	10 44 ...	17 20 ...	1 15·8 ...	6 22 N.
Mars......	16 45 ...	22 25 ...	4 5*...	12 58·3 ...	4 38 S.
Jupiter....	21 25*...	1 40 ...	5 55 ...	16 9·9 ...	20 1 S.
Saturn....	9 40 ...	17 38 ...	1 36*...	8 10·8 ...	20 40 N.
Uranus...	16 42 ...	22 20 ...	3 58*...	12 53·2 ...	4 58 S.
Neptune..	5 35 ...	13 17 ..	20 59 ...	3 48·6 ...	18 21 N.

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

Occultations of Stars by the Moon (visible at Greenwich).

May.	Star.	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image.
			h. m.	h. m.	° °
1 ...	50 Sagittarii ...	6 ...	3 19 ...	3 33 ...	359 339
3 ...	31 Capricorni ...	6½ ...	2 50 ...	3 43 ...	112 214

May.	h.	
5 ...	18 ...	Mars in conjunction with and 0° 35′ north of Uranus.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·4	81 16 N.	May 2,	2 40	*m*
ζ Geminorum ...	6 57·5	20 44 N.	Apr. 29,	20 0	*m*
U Monocerotis ...	7 25·5	9 33 S.	May 1,		*M*
T Geminorum ...	7 42·6	24 1 N.	Apr. 29,		*M*
R Crateris	10 55·1	17 43 S.	,, 30,		*m*
T Ursæ Majoris ...	12 31·3	60 6 N.	May 2,		*M*
U Boötis	14 49·2	18 9 N.	Apr. 29,		*M*
δ Libræ	14 55·0	8 4 S.	May 1,	21 38	*m*
U Coronæ	15 13·6	32 3 N.	Apr. 30,	22 56	*m*
U Ophiuchi... ...	17 10·9	1 20 N.	May 2,	2 10	*m*
W Sagittarii ...	17 57·9	29 35 S.	,, 5,	3 0	*M*
R Scuti...	18 41·5	5 50 S.	Apr. 29,		*M*
β Lyræ...	18 46·0	33 14 N.	May 5,	1 0	*M*
S Sagittæ	19 50·9	16 20 N.	Apr. 30,	0 0	*m*
			May 3,	0 0	*M*
T Delphini	20 40·2	16 0 N.	,, 1,		*M*
T Vulpeculæ ...	20 46·7	27 50 N.	Apr. 30,	22 0	*M*
			May 1,	23 0	*m*
δ Cephei	22 25·0	57 51 N.	Apr. 29,	21 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near ζ Ursæ Majoris ...	206°	57° N.	Slow, bright.
,, β Libræ	228	5 S.	Rather slow.
,, δ Serpentis	233	10 N.	Swift.
,, υ Herculis	239	46 N.	Swift, faint.
,, ξ Ophiuchi	255	21 S.	Rather slow, long.
,, η Aquarii	337	2 S.	Swift, long, streaks.

GEOGRAPHICAL NOTES.

THE Founder's Medal of the Royal Geographical Society has been awarded to Mr. Clements R. Markham, C.B., F.R.S., on his retirement, after twenty-five years' service, from the Honorary Secretaryship of the Society, during which he has done so much for the promotion of geography. The announcement of Mr. Markham's retirement will be received with regret by all who know the value of the work he has done, both in connection with the Society and otherwise. But as he is still in his vigour we may look for many more years' good work from him. The Royal Medal has been awarded to Lieut. Wissmann, who has twice crossed Africa, and done a great amount of excellent exploring work in the region south of the Congo. The Murchison Grant has been awarded to Mr. James McCarthy, Superintendent of Surveys in Siam; the Gill Premium to Mr. Charles M. Doughty, for his explorations in Arabia; and the Cuthbert Peek Grant to Major Festing for his services as cartographer on the Gambia River. As honorary corresponding members, have been selected Dr. G. Radde, of Tiflis, Dr. H. Rink, of Copenhagen, and Dr. Rein, Professor of Geography at Bonn University.

Two papers were read at Monday's meeting of the Royal Geographical Society, one by the Rev. T. S. Lea, on the Island of Fernando Noronha, and the other by Colonel Sir Marshall Clarke, on Basuto Land. Mr. Lea accompanied Mr. H. N. Ridley on his mission to Fernando Noronha last year. The islands are 290 miles north-east of Pernambuco. The total length of the whole group from north-east to south-west is about 6¼ geographical miles, and the maximum width of Fernando itself 1½ mile. The north-east cape of that island is very rugged and precipitous, though of no great height. Boobie Island and Egg Island are also raised masses of reef rock, which again appears on the top of the basalt of Platform Island. Mount St. Michael is a phonolite peak on which the weed invasion has hardly found a footing, and the native plants still flourish. This phonolite is a gray, close-grained columnar rock, and it seems to be the key to the very interesting geology of the island. Platform Island and Egg Island have a connection at low water with the main island, a small mass of reef rock. Morro do Chapeo, or the Hat Rock, seems to represent the residue of a larger block. The north cape of the main island is stony, and there is no great wealth of vegetation, though even here many of the endemics may be found. There is a patch of blown sand at San Antonio over which the *Ipomœa pes-capræ* trails, and beyond that the ground rises towards the basaltic height on which the town is built. The basalt is more inclined to be nodular than columnar. Descending from the town hills, the peak stands out clear against the northern sky. It is a huge mass of columnar phonolite, with a talus of *débris* around it, in shape not unlike a church with a tower. About the centre of the plain rises a round mass of phonolite. On the south coast, like bastions, stand two other phonolite masses, with a ridge of basalt between them, steep on its seaward side, but sloping gradually landwards. The islands of the south coast, with the exception of the minute I. Jones, are also phonolite. Tobacco Point is basaltic, and Morro Branco, in Leão Bay, altered phonolite. There are raised beaches of reef rock on Tobacco Point and to the east of Look-out Hill. Mr. Lea hazards the following observations with regard to the structure and possible history of the main island. Though undoubtedly volcanic in origin, the date at which it was in any way active must be exceedingly remote. No hot springs, or any trace of them, occur; no earthquakes or tidal waves are felt. No site of a crater can be pointed to with certainty, and indeed any attempt to reconstruct its pristine shape from the attenuated remains that are left us must be undertaken with extreme diffidence. As the island is surrounded by deep sea, and as nothing volcanic occurs, as far as he is aware, on the coast of Brazil in its neighbourhood, he is inclined to think that it marks the site of an isolated vent. The number of species of plants, &c., peculiar to the island seems also to point to this, or at any rate to the extreme remoteness of any connection with other land. But there is at least one thing which may throw some light on this matter. All round the island, though interrupted in places, especially on the northern coast, there is a sort of reef formation laid bare at low water, and closely resembling the Recife of Pernambuco. At certain points a very similar rock is found at considerable heights above the sea. On Rat Island this reef attains no great elevation. It rests upon a beach of rounded boulders near the landing, which may be seen underlying it. Boobie Island and Egg Island also have it, and there are traces of it at the summit of Platform Island. On basalt in Cotton-tree Bay, close by Look-out Hill, it occurs at a yet greater height, and again on Tobacco Point and I. Jones it also occurs above high-water mark. Raised beaches, therefore, seem only to exist on basalt, and in close connection with a phonolite peak. Mr. Lea suggests that the phonolite regions mark the sites of the ancient vents of the volcano, the phonolite itself being the plug which remained fixed during subsequent eruptions of lava. The scoria is all but gone, only remaining where the basalt covers it, but the harder phonolite still remains in its place, and the raised beaches show that beneath it lay the forces which manifested themselves in the last expiring efforts of the volcano. The flora and fauna of the group have already been very fully described by Mr. Ridley.

SIR MARSHALL CLARKE's paper described an official tour he made in Basuto Land, last October, to visit the Baltokoa tribe settled among the mountains. He traversed 400 miles of country, a large proportion of which had never been visited by Europeans. The highest point attained was 10,750 feet; but from thence, both north and south, distant heights appeared at great elevations.

ANTAGONISM.[1]

SOME months ago, shortly after I had resigned my office of Judge of the High Court, I was expressing to a friend my fear of the effect of having no compulsory occupation, when he said, by way of consolation, "Never mind, 'for Satan finds some mischief still for idle hands to do.'" You may possibly in the course of this evening think he was right. I have chosen a title for my lecture which may not fully convey to your minds the scope of the views which I am going to submit to you. I propose to adduce some arguments to show that "antagonism," a word generally used to signify something disagreeable, pervades all things; that it is not the baneful thing which many consider it; that it produces at least quite as much good as evil; but that, whatever be its effect, my theory—call it, if you will, speculation—is that it is a necessity of existence, and of the organism of the universe so far as we understand it; that motion and life cannot go on without it; that it is not a mere casual adjunct of Nature, but that without it there would be no Nature, at all events as we conceive

[1] Lecture delivered at the Royal Institution, on April 20, by the Right Hon. Sir William R. Grove, F.R.S.

it; that it is inevitably associated with unorganized matter, with organized matter, and with sentient beings.

I am not aware that this view, in the breadth in which I suggest it, has been advanced before. Probably no idea is new in all respects in the present period of the world's history. It has been said by a desponding pessimist that "There is nothing new, and nothing true, and nothing signifies," but I do not entirely agree with him; I believe that in what I am about to submit there is something new and true in the point of view from which I regard the matter; whether it signifies or not is for you to judge.

The universality of antagonism has not received the attention it seems to me to deserve from the fact of the element of force, or rather of the conquering force, being mainly attended to, and too little note taken of the element of resistance unless the latter vanquishes the force, and then it becomes, popularly speaking, the force, and the former force the resistance.

There are propositions applying more or less to what I am going to say of some antiquity.

Heraclitus, quoted by Prof. Huxley, said: "War is the father and king of all things." Hobbes said war is the natural state of man, but his expressions have about them some little ambiguity. In Chapter I. of the "De Corpore Politico" he says "Irresistible might in a state of nature is right," and "The estate of man in this natural liberty is war." Subsequently he says: "A man gives up his natural right, for when divers men having right not only to all things else, but to one another's persons, if they use the same there arizeth thereby invasion on the one part and resistance on the other, which is war and therefore *contrary to the law of Nature, the sum whereof consisteth in making peace*." I can only explain this apparent inconsistency by supposing he meant "law of Nature" to be something different from "the natural estate of man," and that the making peace was the first effort at contract, or the beginning of law; but then why call it the "*law of Nature*," where he says might is right? There is however some obscurity in the passage.

The Persian divinities, Ormuzd and Ahriman, were the supposed rulers or representatives of good and evil, always at war, and causing the continuous struggles between human beings animated respectively by these two principles. Undoubtedly good and evil are antagonistic, but antagonism, as I view it, is as necessary to good as to evil, as necessary to Ormuzd as to Ahriman. Zoroaster's religion of a Divine being, one and indivisible, but with two sides, is, to my mind, a more philosophical conception. The views of Lamarck on the modification of organic beings by effort, and the establishment of the doctrine of Darwin as to the effects produced by the struggle for existence and domination, come much nearer to my subject. Darwin has shown how these struggles have modified the forms and habits of organized beings, and tended to increased differentiation, and Prof. Huxley and Herbert Spencer have powerfully promoted and expanded these doctrines. To the latter we owe the happy phrase, "survival of the fittest," and Prof. Huxley has recently, in a paper in the *Nineteenth Century*, anticipated some points I should have adverted to as to the social struggles for existence. To be anticipated, and by a very short period, is always trying, but it is more trying when what you intended to say has been said by your predecessor in more terse and appropriate language than you have at your command.

I propose to deal with "antagonism" inductively, *i.e.* with facts derived from observation alone, and not to meddle with spiritual matters or with consequences.

Let us begin with what we know of the visible universe, viz. suns, planets, comets, meteorites, and their effects. These are all pulling at each other, and resisting that pull by the action of other forces.

Any change in this pulling force produces a change, or, as it is called, perturbation, in the motion of the body pulled. The planet Neptune, as you know, was discovered by the effect of its pulling force on another planet, the latter being deflected from its normal course. When this pulling force is not counterbalanced by other forces, or when the objects pulled have not sufficient resisting power, they fall into each other. Thus, this earth is daily causing a bombardment of itself by drawing smaller bodies—meteorites—to it; 20,000,000 of which, visible to the naked eye, fall on an average into our atmosphere in each twenty-four hours, and of those visible through the telescope, 400,000,000 are computed to fall within the same period. Mr. Lockyer has recently given reasons for supposing the luminosity of nebulæ, or of many of them, is due to collisions or friction among the meteorites which go to form them; but his paper on the subject is not yet published. You must get from Mr. Lockyer the details of his views. I hope he may, at one of these evening meetings, give you a *résumé* of them from the place I now occupy.

What is commonly called centrifugal force does not come from nothing; it depends upon the law that a body falling by the influence of attraction, not upon, but near to, the attracting body, whirls round the latter, describing one of the curves known as conic sections. Hence, a meteorite may become a planet or satellite (one was supposed to have become so to this earth, but I believe the observations have not been verified); or it may go off in a parabola as comets do; or, again, this centrifugal force may be generated by the gradual accretion of nebulous matter into solid masses falling near to, or being thrown off from, the central nucleus, the two forces, centrifugal and centripetal, being antagonistic to each other, and the relative movements being continuous, but probably not perpetual. Our solar system is also kept in its place by the antagonism of the surrounding bodies of the Kosmos pulling at us. Suppose half of the stars we see, *i.e.* all on one side of a meridian line, were removed, what would become of our solar system? It would drift away to the side where attraction still existed, and there would be a wreck of matter and a crash of worlds. It is very little known that Shakespeare was acquainted with this pulling force. He says, by the mouth of Cressida—

> "But the strong base and building of my love
> Is as the very centre of the earth
> Drawing all things to it"—

a very accurate description of the law of gravitation, so far as this earth is concerned, and written nearly a century before Newton's time.

But in all probability the collisions of meteorites with the earth and other suns and planets are not the only collisions in space. I know of no better theory to account for the phenomena of temporary stars, such as that which appeared in 1866, than that they result from the collision of non-luminous stars, or stars previously invisible to us. That star burst suddenly into light, and then the luminosity gradually faded, the star became more and more dim, and ultimately disappeared. The spectrum of it showed that the light was compound, and had probably emanated from two different sources. It was probably of a very high temperature. If this theory of temporary stars be admitted, we get a nebula of vapour or star dust again, and so may get fresh instances of the nebular hypothesis.

Let us now take the earth itself. It varies in temperature, and consequently the particles at or near its surface are in continuous movement, rubbing against each other, being oxidized or deoxidized, either immediately or through the medium of vegetation. This also is continuously tearing up its surface and changing its character. Evaporation and condensation, producing rain, hail, and storms, notably change it. Force and resistance are constantly at play. The sea erodes rocks and rubs them into sand. The sea quits them and leaves traces of its former presence by the fossil marine shells found now at high altitudes. Rocks crumble down and break other rocks or are broken by them; avalanches are not uncommon. The interior of the earth seems to be in a perpetual state of commotion, though only recurrent to our observation. Earthquakes in various places from time to time, and, doubtless, many beneath the sea of which we are not cognizant, nor of other gradual upheavals and depressions. Throughout it nothing that we know of is at rest, and nothing can move without changing the position of something else, and this is antagonism. Metals rust at its surface, and probably they or their oxides, chlorides, &c., are in a continuous state of change in the interior. Nothing that we know of is stationary. The earth as a whole seems so at first sight, but its surface is moving at the rate of some seventeen miles a minute at the equator; and standing at either of the Poles—an experiment which no one has yet had an opportunity of trying—a man would be turned round his own axis once in every twenty-four hours, while the earth's motion round the sun carries us through space more than a million and a half of miles a day.

The above changes produce motion in other things. The earth pulls the sun and planets, and in different degrees at different portions of its orbit.

Before I pass from inorganic to organized matter I had better deal with what may perhaps strike you as the most difficult part of my subject, viz. light. Where, you may say, is there antagonism in the case of light? Light exercises its force upon such minute portions of matter that until the period of the discovery of photography its physical and chemical effects were almost unknown. Such effects as bleaching, uniting some gases, and affecting the colouring matter of vegetables, were partly known but little attended to; but photography created a new era: I shall advert to this presently. The theories of light, however, involved matter and motion. The corpuscular theory, as you well know, supposed that excessively small particles were emitted from luminous bodies, and travelled with enormous velocity. The undulatory theory, which supplanted it, supposed that luminous bodies caused undulations or vibrations in a highly tenuous matter called ether, which is supposed to exist throughout the interplanetary spaces and throughout the universe so far as we know it. Some suppose this ether to be of a specific character differing from that of ordinary gases, others that it is in the nature of a highly attenuated gas; but, whatever it be, it cannot be affected by undulations or vibrations without being moved, and when matter is moved by any force it must offer resistance to that force, and hence we get antagonism between force and resistance. Light also takes time in overcoming this resistance, *i.e.* in pushing aside the ether. It travels no doubt at a good pace—about 190,000 miles in a second; but even at this rate, and without being particular as to a few millions of miles, it takes three years and a quarter to reach us from the star which, so far as we know, is the nearest to us, viz. α Centauri. The ether, or whatever it may be called, tenuous as it is, is not unimportant, though it be not heavy. Without it we should have no light and possibly no heat, and the consequences of its absence would be rather formidable. I believe you have heard Dr. Tyndall on this subject. Supposing the visible universe to be as it is now supposed to be, *i.e.* in no part a mere vacuum, there can be no force without resistance in any part of it.

But photography carries us further, it shows us that light acts on matter chemically, that it is capable of decomposing or forcing asunder the constituents of chemical compounds, and is therefore a force met by resistance. In the year 1856 I made some experiments published in the *Philosophical Magazine* for January 1857, which seemed to me to carry still further what I may call the molecular fight between light and chemical affinity, and among them the following. Letters cut out of paper are placed between two polished squares of glass with tin-foil on the outsides. It is then electrized like a Leyden jar, for a few seconds, the glasses separated, the letters blown off, and the inside of one of the glasses covered with photographic collodion. This is then exposed to diffuse daylight, and on being immersed in the nitrate of silver bath the part which had been covered with the paper comes out dark, the remainder of the plate being unaffected. (This result was shown by the electric light lantern.) In this case we see that another imponderable force, electricity, invisibly affects the surface of glass in such a way that it conveys to another substance of definite thickness, viz. the prepared collodion, a change in the chemical relations of the substance (iodide of silver) pervading it, enabling it to resist that decomposition by light which but for some unseen modification of the surface of the glass plate it would have undergone, and no doubt the force of light being unable to effect its object was reflected or dispersed, and instead of changing its mode of motion in effecting chemical decomposition, it goes off on other business. The visible effect is in the collodion film alone. I have stripped that off, and the imprint remains on it, the surface of the glass being, so far as I could ascertain, unaffected. Thus in the film over the protected part, light conquers chemical affinity; in that over the non-protected part, chemical affinity resists and conquers light, which has to make an ignominious retreat. It is a curious chapter in the history of the struggles of molecular forces, and probably similar contests between light and chemical or physical attractions go on in many natural phenomena, some forms of blight and some healthy vegetable changes being probably dependent on the varying effects of light, and conditions, electrical or otherwise, of the atmosphere.

Let us now pass on to organic life. A blade of grass, as Burke, I believe, said as a figure of speech, is fighting with its neighbours. It is robbing them, and they are trying to rob it—no agreement or contract, simply force opposed to force. This struggle is good for the grass; if it got too much nutriment it would become diseased. The struggle keeps it in health. The rising of sap in trees, the assimilation of carbon, the process of growth, the strengthening themselves to resist prevalent winds, and many other instances might be given, which afford examples of the internal and external struggles in vegetable life.

I will now proceed to consider animal life, and in this case I will begin with the internal life of animals, which is a continual struggle. That great pump the heart is continuously beating—that is, conquering resistance. It is forcing the blood through the arteries, they assisting in squeezing it onwards. If they give way the animal dies; if they become rigid and resist too much, the animal dies. There must be a regulated antagonism, a rhythmical pulsation, the very term involving force and resistance. That the act of breathing is antagonistic scarcely needs argument. The muscular action by which the ribs are made to open out and close alternately, in order to inhale and exhale air, and other physiological changes which I cannot here go into, necessitate a continuous fight for life. So with digestion, assimilation, and other functions, mechanical and chemical forces and resistances come into play.

Since this lecture was written, I have heard of a discovery made, I am informed, by Prof. Metschnikoff, and which has brought to light a singular instance of internal antagonism. He is said to have proved that the white corpuscles of the blood are permanent enemies of Bacteria, and by inoculation will absorb poisonous germs; a recurrent war, as it appears, going on between them. If the corpuscle is the conqueror, the Bacteria are swallowed up, and the patient lives. If the corpuscles are vanquished, the patient dies, and the Bacteria live, at all events for a time. If the theory is founded, it affords a strong additional argument to the doctrine of internal antagonism. Possibly if there were no Bacteria, and the corpuscles had nothing to do, it would be worse for them and the animal whom they serve.

Let us now consider the external life of animals. I will take as an instance, for a reason which you will soon see, the life of a wild rabbit. It is throughout its life, except when asleep (of which more presently), using exertion, cropping grass, at war with vegetables, &c. If it gets a luxurious pasture it dies of repletion. If it gets too little it dies of inanition. To keep itself healthy it must exert itself for its food; this, and perhaps the avoiding its enemies, gives it exercise and care, brings all its organs into use, and thus it acquires its most perfect form of life. I have witnessed this effect myself, and that is the reason why I choose the rabbit as an example. An estate in Somersetshire, which I once took temporarily, was on the slope of the Mendip Hills. The rabbits on one part of it, viz. that on the hill-side, were in perfect condition, not too fat nor too thin, sleek, active, and vigorous, and yielding to their antagonists, myself and family, excellent food. Those in the valley, where the pasturage was rich and luxuriant, were all diseased, most of them unfit for human food and many lying dead on the fields. They had not to struggle for life, their short life was miserable and their death early, they wanted the sweet uses of adversity—that is, of antagonism.

The same story may be told of other animals. Carnivora, beasts or birds of prey, live on weaker animals; weaker animals herd together to resist, or, by better chance of warning, to escape, beasts of prey; while they, the Herbivora, in their turn are destroying vegetable organisms.

I now come to the most delicate part of my subject, viz. man (I include women of course!). Is man exempt from this continual struggle?

It is needless to say that war is antagonism. Is not peace so also, though in a different form? It is a common-place remark to say that the idle man is worn out by *ennui*, *i.e.* by internal antagonism. Kingsley's "Do-as-you-like" race—who were fed by a substance dropping from trees, who did no work, and who gradually degenerated until they became inferior to apes, and ultimately died out from having nothing to do, nothing to struggle with—is a caricature illustrative of the matter. That the worry of competition is nearly equivalent to the hardships and perils of military life seems proved to me by the readiness with which military life is voluntarily undertaken, ill as it is paid. If it were well paid, half our men would be in the military or naval service, and I am not sure that we should not have regiments of Amazons! The increased risk of life or limbs and the arduous nature of the work do not prevent men belonging to all classes from entering these services, little remunerative as they are. Others take the risks of travelling in the deserts of Africa or wintering in the Polar regions, of being eaten by lions or frozen to death, of falling from a Swiss mountain or foundering in a yacht, in preference to a life of tranquillity; and sportsmen elect the danger of endeavouring to kill an animal that can and may kill them, to shooting tame pheasants at a *battue* or partridges in a turnip-field.

Then, in what is euphemistically called a life of peace, buyer and seller, master and servant, landlord and tenant, debtor and creditor, are all in a state of simmering antagonism; and the inventions and so-called improvements of applied science and art do not lessen it. Exercise is antagonism; at each step force is used to lift up our bodies and push back the earth; as the eminent Joseph Montgolfier said, that when he saw a company dancing, he mentally inverted his view and imagined the earth dancing on the dancers' feet, which it most unquestionably did. Indeed, his great invention of balloons was guessed at by his witnessing a mild form of antagonism between heat and gravitation. He, being a dutiful husband, was airing his wife's dresses, who was going to a ball. He observed the hot air from the fire inflated the light materials, which rose up in a sort of spheroidal form (you may some of you have noticed this form in dress!). This gave him the idea of the fire-balloon, which, being a large paper-maker at Annonay, he forthwith experimented on, and hence we got aërial navigation. This anecdote was told me by his nephew M. Seguin, also an eminent man. Even what we call a natural death is a greater struggle than that which other animals go through, and is, in fact, the most artificial of all deaths. The lower animals, practically speaking, do experience a natural death, *i.e.* a violent or unforeseen death. As soon as their powers decline to such an extent that they cannot take part in the struggle for existence, they die or are killed, generally quickly, and their sufferings are not protracted by the artificial tortures arising from the endeavours to prolong life.

Let us now pass from individuals to communities. Is there less antagonism now than of yore? Do the nations of Europe now form a happy family? Are the armaments of Continental nations, or is the navy of this country, less than in former years? The very expression "the Great Powers" involves antagonism.

As with wars and revolutions, so, as I have said, with regard to individuals, during our so-called peace, the fight is continuous among communities. If the water does not boil, it simmers. Not merely are there the struggles of poor against rich going on, but the battles for position and pre-eminence are constant. The subjugated party or sect seeks first for toleration, then for equalization, and then for domination.

We call contentment a virtue, but we inculcate discontent. A father reproaches his son for not exerting himself to improve his position, and at school and college and in subsequent periods of life efforts at advancement in the social scale are recommended. Individual antagonisms, class antagonisms, political, trading, and religious antagonisms take the place of war. Can war exhibit a more vigorous and persistent antagonism than competition does? Take the college student with ruined health; take the bankrupt tradesman with ruined family; take the aspirants to fashion turning night into day, and preferring gas or electric light to that of the sun: there is, to be sure, some excuse for this, as we so rarely see the latter. But our very amusements are of a combative character: chess, whist, billiards, racing, cricket, football, &c. And in all these we, in common parlance, speak of *beating* our opponent.

Even dancing is probably a relic and reminiscence of war, and some of its forms are of a military character. I can call to mind only one game which is not combative, and that is the game you are in some sort now playing, viz. "patience," and with, I fear, some degree of internal antagonism!

Take, again, the ordinary incidents of a day's life in London. 15,000 to 20,000 cabs, omnibuses, vans, private carriages, &c., all struggling, the horses pushing the earth back and themselves forwards, the pedestrians doing the same, but the horses compulsorily—they have not as yet got votes. The occupants of the cabs, vans, &c., are supposed to act from free will, but in the majority of cases they are as much driven as the horses. Insolvents trying to renew bills, rich men trying to save what they have got by saving half an hour of time. Imagine, if you can, the friction of all this, and add the bargaining in shops, the mental efforts in counting-houses, banks, &c., and road repair, now a permanent and continuous institution. Take our railways: similar efforts and resistances. Drivers, signal-men, porters, &c., and the force emanating from the sun millions of years ago, and locked up in the coal-fields, as Stephenson suggested, now employed to overcome the inertia of trains and to make them push the earth in this or that direction, and themselves along its surface. Take the daily struggles in commerce, law, professions, and legislation, and sometimes even in science and literature. Politics I cannot enter upon here, but must leave you to judge whether there is not some degree of antagonism in this pursuit. In all this there is plenty of useful antagonism, plenty of useless—much to please Ormuzd and much to delight Ahriman; but of the two extremes, over-work or stagnation, the latter would, I think, do Ahriman's work more efficiently than the former. We cry peace when there is no peace. Would the world, however, be better if it were otherwise? Is the Nirvana a pleasing prospect? Sleep, though not without its troubles and internal antagonism, is our nearest approach to it, but we should hardly wish to be always asleep.

Shakespeare not only knew something about gravitation, but he also knew something about antagonism. He says, by the mouth of Agamemnon—

> "Sith every action that hath gone before
> Whereof we have record, trial did draw
> Bias and thwart, not answering the aim,
> And that unbodied figure of the thought
> That gav't surmised shape."

In no case is the friction of life shown more than in the performance of "duty," *i.e.* an act of self-resistance, a word very commonly used; but the realization of it is by no means so frequent. Indeed, faith in its performance so yields to scepticism that it is said that when a man talks of doing his duty, he is meditating some knavish trick.

The words good and evil are correlative: they are like height and depth, parent and offspring. You cannot, as far as I can see, conceive the existence of the one without involving the conception of the other. In their common acceptation they represent the antagonism between what is agreeable or beneficial and what is painful or injurious.

An old anecdote will give us the notion of good and evil in a slenderly educated mind. A missionary having considered that he had successfully inculcated good principles in the mind of a previously untutored savage, produced him for exhibition before a select audience, and began his catechism by asking him the nature of good and evil. "Evil," the pupil answered, "is when other man takes my wife." "Right," said the missionary, "now give me an example of good." The answer was: "Good is when me takes other man's wife." The answer was not exactly what was expected, but was not far in disaccord with modern views among ourselves and other so-called civilized races. I don't mean as to running away with other men's wives! But we still view good and evil very much as affecting our own interests. At the commencement of a war each of the opposing parties view victory—*i.e.* the destruction of their enemies—as good, and being vanquished as evil. Congregations pray for this. Statesmen invoke the God of battles. Those among you who are old enough will call to mind the Crimean War. Each combatant nation gives thanks for the destruction of the enemy, each side possibly believing that they respectively are in the right, but in reality not troubling themselves much about that minor question. We (unconsciously perhaps) "compound for sins we are inclined to by damning those we have no mind to." So in the daily life of what is called peace. The stage-coach proprietor rejoiced when he had driven his rival off the road, railway directors and shareholders now do the same, so do publicans, shopkeepers, and other rivals. We are still permeated by the old notion of good and evil. But "antagonism," as I view it, not only comprehends the relation of good and evil, but, as I have said, produces both, and is as necessary to good as to evil. Without it there would be neither good nor evil. Judging of the lives of our progenitors from what we see of the present races of men of less cerebral development, we may characterize them as having been more impulsive than ourselves, and as having their joys and sorrows more quickly alternated. After the hunt for food, accompanied by privation and suffering, comes the feast to gorging. Their main evil was starvation, their good repletion. Even now the Esquimaux watches a seal-hole in the bitter cold for hours and days, and his compensation is the spearing and eating the seal. The good is resultant upon and in the long run I suppose equivalent to the evil. These men look not back into the past, and forward into the future as we do. We, by extending our thought over a wider area, are led to more continuing sacrifices, and aim at more lasting enjoyment in the result. The child suffers at school in order that his future life may be more prosperous. The man spends the best part of his life in arduous toil, physical or mental, in order that he may not want in his later years, or that his family may reap the benefit of his labour. Further-seeing men spend their whole lives on work little remunerative that succeeding generations may be benefited. The prudent man transmits health and wealth to his descendants, the improvident man poverty or gout. One main element of what we call civilization is the capability of looking further back into the past, and further forward into the future; but, though measured on a different scale, the average antagonism and approximate equivalence appear to me to be the same.

Can we suppose a state of things either in the inorganic or the organic world which, consistently with our experience or any deduction drawn from it, would be without antagonism? In the inorganic world it would be the absence of all movement, or, what practically amounts to the same thing, movement of everything in the same direction, and the same relative velocity; for, as movement is only known to us by relation, movement where nothing is stationary or moving in a different direction or with a different velocity would be unrecognizable.

So in the organic but non-sentient world, if there were no no struggle, no absorption of food, no growth, nothing to overcome, there would be nothing to call life. If, again, in the sentient world there were no appetites, no hopes—for both these involve discontent—no fear, no good or bad, what would life be? If fully carried out, is not a life without antagonism no life at all, a barren metaphysical conception of existence, or rather alleged conception, for we cannot present to the mind the form of such conception?

In the most ordinary actions, such as are necessary to sustain existence, we find, as I have already pointed out, a struggle more or less intense, but we also find a reciprocal interdependence of effort and result. The graminivorous animal is during his waking hours always at work, always making a small but continuous effort, selecting his pastures, cropping vegetables, avoiding enemies, &c. The Carnivora suffer more in their normal existence; their hunger is greater, and their physical exertion when they are driven by hunger to make efforts to obtain food is more violent than with the Herbivora, if they capture their prey by speed or battle, or their mental efforts are greater if they capture it by craft. But then their gratification is also more intense, and thus there is a sort of rough equation between their pain and their pleasure, the more sustained the labour the more permanent is the gratification.

As, with food or exercise, deficiency is as injurious in one as is excess in another direction, so, as affecting the mind of communities, as I have stated it to be with individuals, the effect of a life of ease and too much repose is as much to be avoided as a life of unremitting toil. The Pitcairn islanders, who managed in some way to adapt their wants to their supply and to avoid undue increase of population, are said never to have reached old age. In consequence of the uneventful, unexcited lives they led, they died of inaction, not from deficiency of food or shelter, but of excitement. They should have migrated to England! They died as hares do when their ears are stuffed with cotton, *i.e.* from want of anxiety. We have hope in our suffering, and in the mid gush of our pleasures something bitter surges up.

> "We look before and after, and pine for what is not,
> Our sincerest laughter with some pain is fraught,
> Our sweetest songs are those which tell of saddest thought."

The question may possibly occur to you, Have we more or less antagonism now than in former times? We certainly have more complexity, more differentiation, in our mental characteristics, and probably in our physical, so far as the structure of the brain is concerned; but is there less antagonism? With greater complexity come increased wants, more continuous cares. Higher cerebral development is accompanied with greater nervous irritability, with greater social intricacies—we have more frequent petty annoyances, and they affect us more. With all our so-called social improvements, is there not the same struggle between crime and its repression? If we have no longer highway robberies, how many more cases of fraud exist, most of it not touched by our criminal laws? As to litigation I am perhaps not an impartial judge, but it seems to me that if law were as cheap as is desired, every next-door neighbour would be in litigation. It would seem as if social order had never more than the turn of the scale which is necessary to social existence in its favour when contrasted with the disorganizing forces. Without that there would be perpetual insurrections and anarchy. But though antagonism takes a different form it is still there. Are wars more regulated by justice than of yore? I venture to doubt it, though probably many may disagree with me. National self-interest or self-aggrandisement is, I think, the predominant factor, and is frequently admittedly so. I also doubt if the old maxim "If you wish for peace, prepare for war," is of much value. Large armaments and improvements in the means of destruction (whose inventors are more thought of than the discoverers of natural truths) are as frequently the cause of war as of its prevention. Are wars less sanguinary with 100-ton guns than with bows and arrows? I cannot enter into statistics on this subject, but a sensible writer who has, viz. Mr. Finlaison, came to the conclusion that wars ceased now as anciently, not in the ratio of the improvements in killing implements, but from exhaustion of men or means. Wars undoubtedly occur at more distant intervals, or the human race would become extinct. Probably the largely increased competition supplies their place: we fight commercially more and militarily less. It is a sad reflection that man is almost the only animal that fights, not for food or means of life or of perpetuating its race, but from motives of the merest vanity, ambition, or passion. War is, however, not wholly evil. It develops noble qualities—courage, endurance, self-sacrifice, friendship, &c.—and tends to get rid of the silly incumbrances of fashion and ostentation. But do the much be-praised inventions of peace bring less antagonism? Consider the enormous labour and waste of time due to competition in the advertizing system alone. Paper-making, type-founding, printing, pasting, posting or otherwise circulating, sandwich-men, &c., all at work for purposes which I venture to think are in great part useless; and those who might add to the productiveness of the earth, or to the enriching our knowledge, are helping to extend the limits of the black country, and wasting their time in interested self-laudation. And the consumer pays the costs. "Buy my clothing, which will never wear out." "Become a shareholder in our Company, which will pay cent. per cent." "Take my pills, which will cure all diseases," &c. These eulogies come from those highly impartial persons the advertisers, all promising golden rewards, but, as with the alchemists, on condition that gold be paid in advance for their wares; and the silly portion of the public, no small body, take them at their word. Though you may not fully agree in this my anathema of the advertising system, and though there may be some small modicum of good in it, I think you will agree that it affords a notable illustration of antagonism. If I were a younger man, I think I should go to Kamchatka to avoid the penny post; possibly I should not be satisfied when I got there. Civilization begins by supplying wants, and ends by creating them, and each supply for the newly-created want begets other wants, and so on "*toties quoties*."

As far as we can judge by its present progress, mankind seems tending to an automatic state. The requirements of each day are becoming so numerous as to occupy the greater portion of that day; and when telegrams, telephones, electro-motion, and numerous other innovations which will probably follow these, reach their full development, no time will be left for thought, repose, or any spontaneous individual action. In this mechanical state of existence, in times of peace, extremes of joy and sorrow, of good and evil, will become more rare, and the necessary uniformity of life will reduce passion and feeling to a continuous petty friction. The converse of the existence contemplated by the Stoics will be attained, and, instead of a life of calm contemplation, our successors will have a life of objectless activity. The end will be swallowed up in the means. It will be all pursuit and no attainment. Is there a *juste milieu*, a point at which the superfluous *commoda vitæ* will cease? None probably would agree at where that point should be fixed, and the future alone can show whether the human race will emancipate itself from being, like Frankenstein, the slave of the monster it has created. In the cases I have given as illustrations—and many more might be adduced—the evil resulting from apparently beneficial changes is not a mere accident: it is as necessary a consequence as re-action is a consequence of action. In the struggle for existence or supremacy, inevitable in all social growths, the invention, enactment, &c., intended to remedy an assumed evil will be taken advantage of by those for whom it is not intended; the real grievance will be exaggerated by those having an interest in trading on it, and the remedy itself will have collateral results not contemplated by those who introduce the change. I could give many instances of this by my own experience as an advocate and judge, but this would lead me away from my subject. Evils, indeed, result from the very change of habit induced by the alleged improvement. The carriage which saves fatigue induces listnessness, and tends to prevent healthy exercise. The knife and fork save the labour of mastication, but by their use there is not the same stimulus to the salivary glands, not the full healthy amount of secretion, whereby digestion suffers; there is not the same exercise of the teeth whereby they are strengthened and uniformly worn, as we see in ancient skulls. It seems not improbable that their premature decay in civilized nations is due to the want of their normal exercise by the substitution of the knife and fork and stew-pan. According to the evolution theory, our organs have grown into what they are, or ought to be, by long use, and the remission of this tends to irregular development, or atrophy. Every artificial appliance renders nugatory some pre-existing mode of action, either voluntary or involuntary; and as the parts of the whole organism have become correlated, each part being modified by the functions and actions of the others, every part suffers more or less when the mode of action of any one part is changed. So with the social structure, the same correlation of its constituent parts is a necessary consequence of its growth, and the change of one part affects the well-being of other parts. All change, to be healthy, must be extremely slow, the defect struggling with the remedy through countless but infinitesimally minute gradations.

Lastly, so the forms of government give us any firm ground to rest upon as to there being less undue antagonism in one than in another form. Whether it is better to run a risk of, say, one chance in a thousand or more of being decapitated unjustly by a despot, or to have what one may eat or drink, or whom one may marry, decided by a majority of parish voters, is a question on which opinions may differ, but there is abundant antagonism in either case.

Communism, the dream of enthusiasts, offers little prospect of ease. It involves an unstable equilibrium, *i.e.* it consists of a chain of connection where a defect in one link can destroy the working of the whole system, and why the executive in that system should be more perfect than in others I never have been able to see. Antagonism, on the other hand, tends to stability. Each man working for his own interests helps to supply the wants of others, thus ministering to public convenience and order, and if one or more fail the general weal is not imperilled.

You may ask, Why this universal antagonism? My answer is, I don't know; Science deals only with the How? not with the Why? Why does matter gravitate to other matter, with a force inversely as the square of the distance? Why does oxygen unite with hydrogen? All I can say is that antagonism is, to my mind, universal, and will, I believe, some day be considered as much a law, as the law of gravitation. If matter is, as we believe, everywhere, even in the interplanetary spaces, and if it attracts and moves other matter, which it apparently must do, there must be friction or antagonism of some kind. So with organized beings, Nature only recognizes the right, or rather the power, of the strongest. If twenty men be wrecked on a secluded island which will only support ten, which ten have a right to the produce of the island? Nature gives no voice, and the strongest take it. You may further ask me, *Cui bono?* what is the use of this disquisition? I should answer, If the views be true, it is always useful to know the truth. The greatest discoveries have appeared useless at the time. Kepler's discovery of the relations of the planetary movements appeared of no use at the time; no one would now pronounce it useless. I can, however, see much probable utility in the doctrine I have advocated. The conviction of the necessity of antagonism, and that without it there would be no light, heat, electricity, or life, may teach us (assuming free will) to measure effort by the probable result and to estimate the degree of probability. It may teach us not to waste our powers on fruitless objects, but to utilize and regulate this necessity of existence; for, if my views are correct, too much or too little is bad, and a due proportion is good (like many other useful things, it is best in moderation), to accept it rather as a boon than a bane, and to know that we cannot do good without effort—that is, without some suffering.

I have spoken of antagonism as pervading the universe. Is there, you may ask, any limit in point of time or space to force? If there be so, there must be a limit to antagonism. It is said that heat tends to dissipate itself, and all things necessarily to acquire a uniform temperature. This would in time tend practically, though not absolutely, to the annihilation of force and to universal death; but if there be evidence of this in our solar system and what we know of some parts of the universe, which probably is but little, is there no conceivable means of reaction or regeneration of active heat? There is some evidence of a probable zero of temperature for gases as we know them, *i.e.* a temperature so low that at it matter could not exist in a gaseous form; but passing over gases and liquids, if matter becomes solid by loss of heat, such solid matter would coalesce, masses would be formed, these would gravitate to each other, and come into collision. It would be the nebular hypothesis over again. Condensation and collisions would again generate heat; and so on *ad infinitum.*

Collisions in the visible universe are probably more frequent than is usually supposed. New nebulæ appear where there were none before, as recently in the constellation of Andromeda. Mr. Lockyer, as I have said, considers that they are constant in the nebulæ; and if there be such a number of meteorites as are stated to fall daily into the atmosphere of this insignificant planet, what numbers must there be in the universe? There must be a sort of fog of meteorites, and this may account, coupled with possibly some dissipation of light or change of it into other forces, for the smaller degree of light than would be expected if the universe of stellar bodies were infinite. For if so, and the stars are assumed to be of an equal average brightness, then if no loss or obstruction, as light decreases as the square of the distance and stars increase in the same ratio, the night would be as brightly illuminated as the day. We are told that there are stars of different ages—nascent, adolescent, mature, decaying, and dying; and when some of them, like nations at war, are broken up by collision into fragments or resolved into vapour, the particles fight as individuals do, and like them end by coalescing and forming new suns and planets. As the comparatively few people who die in London to-night do not affect us here, so in the visible universe one sun or planet in a billion or more may die every century and not be missed, while another is being slowly born out of a nebula. Thus worlds may be regenerated by antagonism without having for the time more effect upon the Kosmos than the people now dying in London have upon us. I do not venture to say that these collisions are in themselves sufficient to renew solar life; time may give us more information. There may be other modes of regeneration or renewed activity of the dissipated force, and some of a molecular character. The conversion of heat into atomic force has been suggested by Mr. Crookes. I give no opinion on that, but I humbly venture to doubt the mortality of the universe.

Again, is the universe limited? and if so, by what? Not, I presume, by a stone wall! or if so, where does the wall end? Is space limited, and how? If space be unlimited and the universe of suns, planets, &c., limited, then the visible universe becomes a luminous speck in an infinity of dark vacuous space, and the gases, or at all events the so-called ether, unless limited in elasticity, would expand into this vacuum—a limited quantity of ether into an infinite vacuum! If the universe of matter be unlimited in space, then the cooling down may be unlimited in time. But these are perhaps fruitless speculations. We cannot comprehend infinity, neither can we conceive a limitation to it. I must once more quote Shakespeare, and say in his words, "It is past the infinite of thought." But whatever be the case with some stars and planets, I cannot bring myself to believe in a dead universe surrounded by a dark ocean of frozen ether.

Most of you have read "Wonderland," and may recollect that after the Duchess has uttered some ponderous and enigmatical apophthegms, Alice says, "Oh!" "Ah," says the Duchess, "I could say a good deal more if I chose." So could I; but my relentless antagonist opposite (the clock) warns me, and I will only add one more word, which you will be glad to hear, and that word is—Finis.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The list of Physical Science lectures this term includes Prof. Liveing on Spectroscopic Chemistry, Mr. Robinson on Agricultural Chemistry, Mr. Ruhemann on Gas Analysis and on Aromatic Compounds, Mr. Shaw on Electrolysis, Mr. Wilberforce on Dynamo-electric Machines, Mr. Lyon on Machine Construction.

Prof. Stokes lectures on Hydrodynamics, Dr. Besant on Differential Equations and Solid Geometry, Dr. Glaisher on Theory of Errors, Mr. Stearn on Attractions and Theory of Potential.

In Biology, Mr. Langley is lecturing on the Central Nervous System, Prof. Macalister on the Rudimental Structures of the Human Body, Mr. Gadow on the Morphology of Mammalia recent and extinct, Mr. F. Darwin on the Physiology of Plants (advanced demonstrations).

In Geology, Prof. Hughes lectures on the geology of the neighbourhood of Cambridge, Mr. Marr on Advanced Physical Geology, Mr. Roberts on the Crinoidea.

The above are only a selection out of a long list.

Mr. J. G. Adams, of Christ's College, has been appointed Demonstrator of Pathology on Mr. Rolleston's resignation.

SCIENTIFIC SERIALS.

American Journal of Science, April.—The absolute wave-length of light, by Louis Bell. The final results are here given of the research partially reported in the *Journal* for March 1886. Owing to the wide discrepancies in the value of this constant as determined by various observers and methods, the author gives a brief historical summary of the subject, with a critical discussion of the standards of length, methods, and apparatus employed in the present investigation. The details of the experimental work, together with some remarks on the final results, and some questions of theoretical and practical interest connected with the work of recent experimenters in this field, are reserved for a future number.—History of the changes in the Mount Loa craters; Part 1, Kilauea (continued), by James D Dana. Here are discussed questions connected with the ascensive action in the conduit lavas, the effects of heat, the hydrostatic and other gravitational pressure.—The electromotive force of magnetization, by Edward L. Nichols and William S. Franklin. At the Ann Arbor meeting of the American Association for the Advancement of Science the authors described some singular modifications in the relation of iron to acids which occur when the reaction takes place within the magnetic field. In the present paper, which was read at the New York meeting of the Association in 1887, they deal with the behaviour of iron when that metal acts as one electrode in a voltaic circuit, and is at the same time subjected to magnetization.—Notes on certain rare copper minerals from Utah, by W. F. Hillebrand. A series of rare copper ores, including olivenite, erinite, tyrolite (?), chalcophyllite, clinoclasite, mixite (?), and bronchantite, are here subjected to careful chemical and physical examination.—The Taconic system of Emmons, and the use of the name Taconic in geological nomenclature (continued), by Chas. D. Walcott. The main subject of this paper is the geology of the Taconic area as known to Dr. Emmons, with a comparison of its area as now known. As a result of this comparative study, the author finds that the Lower Taconic is essentially a repetition of the Lower Silurian (Ordovician) of the Champlain Valley, while the Upper Taconic appears to be conformably subjacent to the Stockbridge Limestone of the Lower Taconic, and to include the Potsdam horizon at or near its upper portion.—Three formations of the Middle Atlantic Slope (continued), by W. J. McGee. This paper is occupied with the Appomattox formation, its character, and distribution.—W. Le Conte Stevens describes a new lecture apparatus of an extremely simple character for the demonstration of reflection and refraction phenomena.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 8.—"Further Observations on the Electromotive Properties of the Electrical Organ of *Torpedo marmorata*." By Francis Gotch, Hon. M.A. Oxon., B.A., B.Sc. London, M.R.C.S. Communicated by Prof. J. Burdon Sanderson, F.R.S.

In the present treatise the author details the results of further observations as to the electromotive properties of the electrical organ of Torpedo, the experiments being carried out in October, 1887, at the laboratory of the Société Scientifique d'Arcachon.

I. The first part of the work deals entirely with the phenomena of "irreciprocal conduction" in the organ of Torpedo, as described by du Bois-Reymond.

From du Bois-Reymond's experiments it would appear that the organ possesses the remarkable property of conducting an intense current of short duration, led lengthwise through its columns, better when the current is directed from its ventral to its dorsal surface than when directed the reverse way. The former direction coincides with that of the current of the shock of the organ, and is therefore termed by him "homodromous," the latter, being opposite in direction, is termed "heterodromous." The evidence rests upon the value of the galvanometric deflections obtained when both currents are allowed to traverse a strip of organ and a galvanometric circuit. The deflections are markedly unequal, particularly when induced currents are used, the homodromous effect being always much greater than the heterodromous. The homodromous current must therefore either encounter less resistance than the heterodromous, or its electromotive force must be suddenly strengthened, and that of the heterodromous current weakened, by the sudden establishment in the tissue of a new source of electromotive energy. The first is the view taken by Prof. du Bois-Reymond.

(1) The present rheotome experiments reveal (*a*) the new fact that the passage of such intense currents of short duration is always followed by an excitatory response (shock) in the tissue; (*b*) that if the intense current due to this response is allowed to affect the galvanometer as well as the induced or other exciting current, then by obvious algebraic summation the homodromous deflection must be much larger than the heterodromous; (*c*) and that when by means of a fast-moving rheotome the induction shock only is allowed to affect the instrument, no irreciprocity is found.

The author therefore assumes that the phenomena of irreciprocal conduction are in reality excitatory phenomena, the nature of which, from the methods of investigation used, have not been recognized.

(2) The time relations of this response of the isolated strip of the organ to direct stimulation by the traversing induction shock are now for the first time investigated, by means of the rheotome, and the influence of temperature and other conditions upon these is shown by experimental evidence.

II. The second part deals with entirely novel phenomena—namely, the excitation of the organ by the current of its own excitatory state. It is shown that in vigorous summer fish every response of the whole or part of the organ to a single excitation of its nerves is followed by a second response, due to the passage through its own substance of the intense current of the first response. In other words, the shock of the organ excites its own nerve fibres and nerve endings, producing a feebler second shock, which in a similar manner evolves a feebler third shock; this a fourth, and so on.

The response of the isolated organ to nerve excitation is thus multiple; a primary, secondary, tertiary response following the application to the nerve of a single stimulus. Since all these responses produce currents similarly directed through the columns of the organ, each column during its activity must reinforce by its echoes the force of the primary explosion, both in its own substance and also in that of its neighbours.

Linnean Society, April 5.—Mr. W. Carruthers, F.R.S., President, in the chair.—Amongst the exhibitions of the evening Mr. D. Morris (Kew) showed a curious native bracelet from Martinique. Although formed apparently of seeds, or beads of wood, or bone, its real composition had puzzled both botanists and zoologists, and until microscopically examined could not be determined.—Mr. J. G. Baker, F.R.S., exhibited a series of specimens of *Adiantum Fergusoni* and *Capillis Veneris*, and offered some remarks upon their specific and varietal characters.—Mr. J. E. Harting exhibited a specimen of a rare British animal, the pine-marten, which had been trapped in Cumberland; and made some observations on the present distribution of the species in the British Islands.—Mr. Clement Reid exhibited a series of fruits and seeds obtained by Mr. J. Bennie from interglacial deposits near Edinburgh, affording evidence of a colder climate formerly than that now prevailing in the Lowlands of Scotland.—Mr. F. Crisp exhibited some fragmentary remains of a wild goose shot in Somersetshire, which had been reported as the lesser whitefronted goose (*Anser erythropus*, Linn.), but which was apparently an immature specimen of *Anser albifrons*, Scopoli.—In the absence of the author, a paper by Mr. A. W. Waters, on some ovicells of the Cyclostomatous Bryozoa, was read by the Zoological Secretary, Mr. W. Percy Sladen; and after an interesting discussion, the meeting adjourned.

Chemical Society, March 28.—Annual General Meeting.—Mr. W. Crookes, F.R.S., in the chair.—The President delivered an address on which we have already commented.—The following Officers and Council were elected for the ensuing session:—President: Mr. W. Crookes, F.R.S. Vice-Presidents who have filled the office of President: Sir F. A. Abel, F.R.S.; Dr. Warren de la Rue, F.R.S.; Dr. E. Frankland, F.R.S.; Dr. J. H. Gilbert, F.R.S.; Dr. J. H. Gladstone, F.R.S.; Dr. A. W. Hofmann, F.R.S.; Dr. H. Müller, F.R.S.; Prof. Odling, F.R.S.; Dr. W. H. Perkin, F.R.S.; Sir Lyon Playfair, F.R.S.; Sir H. E. Roscoe, F.R.S., and Dr. A. W. Williamson, F.R.S. Vice-Presidents: Prof. G. Carey Foster, F.R.S.; Mr. David Howard; Prof. J. W. Mallet, F.R.S.; Prof. H. McLeod, F.R.S.; Mr. Ludwig Mond; and Prof. Schorlemmer, F.R.S. Secretaries: Prof. H. E. Armstrong, F.R.S., and Prof. J. M. Thomson. Foreign Secretary: Dr. F. R. Japp, F.R.S. Treasurer: Dr. W. J. Russell, F.R.S. Ordinary Members of Council: Prof. T. Carnelly, Mr. A. H. Church, Prof. Clowes, Prof. Dunstan, Dr. P. F. Frankland, Mr. R. J. Friswell, Mr. C. W. Heaton, Mr. E. Kinch, Dr. H. F. Morley, Dr. R. T. Plimpton, Prof. Purdie, and Prof. Ramsay.

April 5.—Mr. W. Crookes, F.R.S., in the chair.—The following papers were read:—Researches on the constitution of azo- and diazo-derivatives; part iii., compounds of the naphthalene β-series, by Prof. R. Meldola, F.R.S., and Mr. F. J. East. —The action of finely divided metals on solutions of ferric salts, and a rapid method for the titration of the latter, by Mr. D. J. Carnegie.

Anthropological Institute, April 10.—Francis Galton, F.R.S., President, in the chair.—Captain Strachan exhibited a young Papuan boy brought by him from the north-west coast of New Guinea.—Mr J. Allen Brown read a paper on some small highly specialized forms of stone implements, found in Asia, North Africa, and Europe.—A paper by MM. Henri and Louis Siret, on the early age of metal in the south-east of Spain, was read.

PARIS.

Academy of Sciences, April 16.—M. Janssen, President, in the chair.—On the spectra of oxygen, by M. J. Janssen. Attention is called to Olszewski's recent experiments with liquefied oxygen, which fully confirm the results of the author's researches on the phenomena of elective absorption in oxygen gas. The bands already determined by him have been observed by Olszewski with a thickness of 7 millimetres of liquid oxygen, while a thickness of from 4 to 5 millimetres would be required to detect the presence of the strongest band, which occurs in the neighbourhood of D. This is a remarkable confirmation of the law of the product of the thickness by the square of the density regulating one of the two systems of bands described by M. Janssen.—On the relations of atmospheric nitrogen to vegetable soil, by M. Th. Schlœsing. This is a reply to the objections recently urged by M. Berthelot against the character of the author's researches, and the general conclusions based on them. He denies the validity of M. Berthelot's criticisms, and insists that he does not deny the fixation of atmospheric nitrogen in vegetable soils. He maintains, however, that the phenomenon is neither determined by his own experiments nor demonstrated with sufficient accuracy by M. Berthelot's analyses.—On a source of algebraic equations whose roots are all real, by M. G. Fouret. An algebraic process is explained, by means of which equations, all of whose roots are real, may be combined in such a way as to obtain from them fresh equations possessing the same property. The following theorem is proposed and discussed: If the equation

$$F(x) \equiv a_0 x^n + a_1 x^{n-1} + a_2 x^{n-2} + \ldots + a_{n-1} x + a_n = 0$$

has all its roots real, then the equation

$$\phi(x) \equiv a_0 f(x) + a_1 f'(x) + a_2 f''(x) + \ldots + a_{n-1} f^{(n-1)}(x) + a_n f^{(n)}(x) = 0,$$

in which $f(x)$ represents an entire polynome of equal or higher degree to n, has at least as many real roots as the equation $f(x) = 0$; and if it has more, the excess is an even number.—On Foucault's gyroscope, by M. E. Guyou. An elementary solution is given of the problem connected with the rotation of a solid body suggested by the movement of this apparatus.—On a new method of measuring the heat of evaporation of liquefied gases, by M. E. Mathias. The calorimetric methods usually employed are either those of *variable* temperature or of the *fixed* temperature of melting ice. But for the purpose of his researches the author has had to employ one of *constant* temperature, the nature and advantages of which are here described. It is specially applicable in the case of gases which, like ethylene, carbonic acid, and the protoxide of nitrogen, have their critical point at the ordinary temperature.—On a class of electric currents set up by the ultra-violet rays, by M. A. Stoletow. Hertz, Wiedemann, and others having shown the influence of the ultra-violet rays on electric discharges at high tension, the author here inquires whether a similar effect may not be obtained with electricity of feeble potential.—On a regulator of electric light, by M. Charles Pollak. In the apparatus here described the movement required to be communicated to the carbons in order to supply and maintain the electric arc is obtained by the thermic expansion of the conducting wires. This appliance, which regulates the electric arc for a period of three hours consecutively, has the advantage of extreme simplicity, dispensing with all intricate mechanism, as well as with electro-magnets.—On a sodico-potassic carbonate, by MM. L. Hugounenq and J. Morel. The authors have obtained this substance by exposing to the open air at a temperature of 12° to 15° C. a solution of carbonate of soda containing carbonate of potassa in the presence of a great excess of iodide of potassium mixed with phosphate and chloride of sodium. It approaches the formula—

$$CO_3K_2,6H_2O + (CO_3Na_2,6H_2O).$$

These researches show generally that the carbonates of soda and of potassa may crystallize together, yielding isomorphous mixtures, which can scarcely be represented by definite formulas. —New experiments on inoculation against rabies, by M. G. Galtier. These experiments, made on sheep and goats, show that herbivorous animals may be successfully preserved from the bite of mad dogs by the usual processes of inoculation, whether applied before or immediately after the attack.—A communication was received from the Minister of Public Instruction announcing the results of the measures recently taken to determine the exact superficial area of France calculated by the planimetric method. This estimate gives 536,408 square kilometres, which is 8012 more than that indicated by the Bureau of Longitudes, and 2929 more than that of the Russian General Strelbitsky.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Outlines of Qualitative Analysis: G. W. Slatter (Murby).—Text-book of Biology: J. R. A. Davis (Griffin).—British Birds: Key List: Colonel L. H. Irby (Porter).—In Pursuit of a Shadow: A Lady Astronomer (Trübner). —A Treatise on Alcohol, 2nd edition: Dr. T. Stevenson (Gurney and Jackson).—Allgemeine Geologie: Dr. Karl von Fritsch (Engelhorn, Stuttgart). —Arithmetic for Beginners: Rev. J. B. Lock (Macmillan).—Nature Readers, Sea-Side and Way-Side, No. 1: J. W. Wright (Heath, Boston).— Mr. Tebbutt's Observatory, Windsor, New South Wales: J. Tebbutt (Sydney).—Bulletin du Musée Royal d'Histoire Naturelle de Belgique, Tome v. No. 1.

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