THURSDAY, APRIL 16, 1891.

OUTLINES OF PSYCHOLOGY.

Outlines of Psychology. By Harald Höffding, Professor at the University of Copenhagen. Translated by Mary E. Lowndes. (London: Macmillan, 1891.)

THIS volume forms one of Messrs. Macmillan's familiar manuals for students. Our first feeling on receiving it was one of regret that for a text-book of psychology in England it should be necessary to have recourse to a translation of a German rendering of a Danish work. But on second thoughts, after perusal, the excellence of the work itself threw our previous regrets into the background.

The first chapter deals with the subject and method of psychology, and it is here at the outset indicated that in the time-honoured classification of psychical states under cognition, feeling, and will, it is not the actual concrete states themselves which are classified, but the elements out of which a closer examination shows them to be formed. Hence these psychological divisions, if they are to have scientific value, must be based on a thoroughgoing analysis. With this we are in full accord. That analysis should precede synthetic speculation we hold to be sound method in psychology; and for this reason, if for no other, we think it an error of judgment in Prof. Höffding's work to introduce at the outset a somewhat scrappy psychogenesis in the child, starting with the debateable assertion that "the beginning of conscious life is to be placed probably before birth," followed by a section to show that the psychology of primitive races teaches that the idea of the mental has passed through the same stages in the history of the human race as in the individual. It would have been better to start with the apparently naïve deliverance of consciousness in the average European man or woman, and to defer the question of genesis either in the individual or the race till a later part of the work.

In the second chapter the interrelation of mind and body is considered. Laying it down that the popular mode of apprehension is distinguished from the scientific in being a compound of experience and metaphysics—a statement so true that it will surprise and annoy many practical common-sense folk—the author points out that, in considering the four hypotheses logically possible, we are in psychology concerned with them only from the point of view of experiential science. The four possible hypotheses are: (1) that consciousness and brain, mind and body, act upon each other as two distinct beings or substances (dualism); (2) that the mind is only a form or a product of the body (materialism); (3) that the body is only a form or a product of one or several mental beings (idealism or monistic spiritualism); and finally (4) that mind and body, consciousness and brain, are evolved as different forms of expression of one and the same being (scientific monism or the identity hypothesis). The consideration of these four views is careful and searching. As an empirical working hypothesis, scientific monism is adopted, but it is wisely noted that "the empirical formula, with which we here end, does not exclude a more comprehensive metaphysical hypothesis."

The third chapter is devoted to the conscious and the unconscious. Here, again, the treatment is clear and guarded, and the very reverse of dogmatic. The conclusion is—and it is the only logical conclusion open to an evolutionist—that the conscious emerges from the unconscious. Prof. Höffding is, however, too careful a reasoner to say that it emerges from neural vibrations; he sees too clearly that consciousness and energy belong to distinct orders of being. But he says: "As the organic world is built up of elements and by means of activities which make their appearance, though more scattered and without unity and harmony, in inorganic nature also, so in the sensations, feelings, and thoughts of conscious beings we should have higher forms of development of a *something* that, in a lower degree and in a lower form, exists in the lower stages of nature." To avoid the awkwardness of the vague "something" which we have italicized, we have (NATURE, vol. xliii. p. 101) suggested the term metakinesis for the whole range of that mode of being which reaches the clearness and intensity of consciousness in the human mind. The conclusion reached, therefore, is that below the level of consciousness there are metakinetic states which are unconscious. And from this it follows that the mental world—as compared with the physical world—is to us a fragment; it is possible to complete it only by means of hypothesis, and even such completion has great difficulties. Moreover, "this fragmentary character of the psychological phenomena, as known to us, makes it impossible for psychology ever to become an exact science, such as physics is already, and as physiology is in process of becoming."

A short chapter on the classification of the psychological elements brings to a conclusion what may be regarded as the general and introductory part of the work. Then follow three long chapters on the psychology of cognition, the psychology of feeling, and the psychology of the will. Into these we do not propose to follow the author. Suffice it to say that they may safely be placed in the hands of psychological students as presenting a logical and well-thought-out development of the scientific or experiential as opposed to the metaphysical study of the human mind. The pages abound in pithy epigrammatic conclusions reminding one of the psychological gems scattered through the writings of George Eliot. There are, too, many references to the instances of keen psychological insight to be found in the works of the poets, and pre-eminently in Shakespeare.

The translation has evidently been done with great care. The sharp crispness of the sentences, and the idiomatic purity of the style, except in a few inconspicuous exceptions, make us forget that we are reading a rendering of a German work. There are, however, one or two words, phrases, or sentences, to which we would direct the translator's attention. On p. 30 we read: "The very first principle on which natural science is based is, that the state of a material point (rest or movement in a straight line) can be altered only through the *movement* of another material point." Should not "movement" be "influence"? Again, would not "stimulus" be more appropriate than "irritant" on p. 50 (in brackets). The word "illusion" is used several times where "delusion" would be more correct (*e.g.* pp. 88, 341).

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On p. 147, in speaking of an observation on after-images, it is said that "they disappeared gradually, but in the spot where they had vanished from the *orbit* of the closed eye," &c. Here the *field* of vision seems to be intended. When we read (p. 107) of "the *marginal* elements to which we are led by analysis of compound states of consciousness," the *ultimate* elements are presumably intended. Is it in accordance with Prof. Höffding's original Danish that the corpora striata and optic thalami are placed in the mesencephalon? These are but slight and scattered blemishes in an excellent piece of work. C. Ll. M.

THE FOUNDATIONS OF GEOMETRY.

The Foundations of Geometry. By E. T. Dixon. (Cambridge: Deighton, Bell, and Co., 1891.)

"OUGHT there not to be a perfect subjective geometry, as well as an applied objective one, the applicability of the former to the latter being a matter to be determined by induction from experiment? It is the object of this book to show that such is the case, to establish the perfect geometry, and to examine the grounds on which we may believe that it applies to the objective space in which we live." Such, stated in the author's own words, is the object he has proposed to himself, and he appeals with confidence to geometricians to criticize his system. The work is divided into three parts, devoted respectively to (1) a discussion on the logical status of geometry; (2) the development of the author's subjective theory; and (3) an investigation into its application to material space. It is to part (2) that we shall chiefly direct our remarks; for though the author's views, as laid down in part (1) (see pp. 20, 21), on definition as the basis of a deductive system, have an important bearing on his geometrical theory, and seem in opposition to those of at least one school of logicians, they will be best tested by an examination of the definitions of the two concepts "direction" and "sameness of direction" laid down at the beginning of part (2). With much of the author's criticism of Euclid's treatment of the plane we are in agreement, but he seems to lay himself open to the chief objections urged against his predecessors. With regard to part (2), *granting the assumptions tacitly made at the outset*, we are willing to admit the formal accuracy of most of the proofs of the propositions in the "subjective theory," and the possibility of supplying it, without any serious derangement of the system, to those which seem to want it. But we do take serious exception to the way in which the foundations of the new edifice are laid. The system is based partly on three axioms, explicitly stated, as to (1) the possible transference of geometrical figures, (2) the possible extension of a straight line, (3) the three-way extension of space; and partly on what are styled, not inaptly, the "implicit" definitions of *position* and *direction*. With that of "position" (used in the sense of "fixed point") we are not much concerned, merely remarking that in it the word *position* is used to explain *position*. This defect, under which Bardolph's more famous definition of "accommodated" also labours, could probably be easily rectified. But so much depends on that of "direction" and "sameness of direction," that we give it in full:—

"Implicit definition of direction.

"(*a*) A direction may be conceived to be indicated by naming two points, as the direction from one to the other.

"(*b*) If a point move from a given position constantly in a given direction, there is only one path, or series of positions, along which it can pass. (Such a path may be called a 'direct path,' and a continuous series of points occupying such positions, a straight line.)

"(*c*) If the direction from A to B is the same as that from B to C, that from A to C is also that same direction.

"(*d*) If two unterminated straight lines, which intersect, are each intersected by a third straight line in two separate points, any unterminated straight line extending in the same direction as this last one, which intersects one of the two former, shall also intersect the other."

Now, we mistrust an "implicit" definition. It seems to be a compound of "axiom and definition" or "postulate and definition," which ought in each case to be carefully analyzed into its elements. As to (*a*) after repeated mental effort, we are still unable to realize the meaning of the "direction from A to B" without using the concept of the "straight line AB." Hence (*b*) seems merely to tell us that moving along the straight line from A to B may be called "moving constantly in the same direction from A to B," and to lay down the *axiom* or *postulate* that "only one straight line can be drawn from A to B," while the only additional explanation given by (*c*) is that if two different straight lines meet their directions are said to be different. As yet we have not received any information as to what is meant when two non-intersecting straight lines are said to have the "same direction" or to have "different directions." We proceed to (*d*) to find what direction from C is that which may be said to be the same as that from A to B. Following the instructions, we must imagine two straight lines OP, OQ, both of which intersect AB, and one of which passes through C; then the straight line which passes through C, and intersects OQ in some point D, such that CD does not intersect AB, however far they are both produced, is said to have the "same direction" as AB.

Surely there is a tacit assumption here *that there is one and only one straight line through C which intersects OQ, and being produced does not intersect AB;* without it the definition seems unmeaning. Yet this afterwards appears as Proposition 2. There is certainly a further one which may be enunciated thus: *If there are two non-intersecting straight lines AB, CD, such that CD meets each of two given intersecting straight lines which each meet AB, then if CD meets either of any other such pair of intersecting straight lines it meets each of them.* If this axiom be not admitted the supposed demonstration of Proposition 2 fails.

It must be clearly understood that we are not objecting to the axioms themselves as fit foundations for a logical system; they seem to be tantamount to those which Euclid either openly or tacitly assumes, or, as it would be better to say, *postulates.* We do not think, indeed, that the author has done his own method justice, for it might be simplified by laying down its αἰτήματα explicitly; and a comparison of them with those tacitly or openly made by Euclid in his definition of a plane, in "Axioms 10 and 12," and in XI. 1–3, would serve to clear up much of the obscurity which it must be confessed has been generally allowed in text-books to hang over this part of the "Elements." It may be incidentally remarked that in Henrici's "Congruent Figures" and Hayward's "Elements of Solid Geometry" these matters receive due discussion. It will serve as a concise summary of the points of contrast between Mr. Dixon's system and that of Euclid as elaborated by commentators to say that, whereas Euclid, starting from the concepts *straightness* and *flatness*, deduces from certain αἰτήματα as to these concepts the concept *parallelism*, Mr. Dixon, starting from the concepts *straightness* and *sameness of direction*, deduces from certain αἰτήματα as to these concepts the concept *flatness*.

While open to the objections we have urged, and to some others on the treatment of the plane angle (we do not, for instance, see any logical cogency in the demonstration of Proposition 7), this part of the work seems to have been elaborated with skill and care.

Part (3) contains some acute remarks on the possibility of a "fourth dimension," and on a method of forming diagrams in material space which shall be "orthogonal projections of the true figures."

We heartily recommend the book to the attention of all those interested in the presentation of the "Elements" to beginners, whether they are authors, teachers, or examiners. Authors may find suggestions for many a note on fundamental difficulties; teachers may pick up a frequent hint for class-work with their more intelligent pupils; and examiners might do worse than set an occasional critical question on some of the assumptions which the author reminds us it is usual to make tacitly. We notice with interest the appearance of a proof of "Axiom 12," which the author, after Prof. Newman, ascribes to M. Vincent, of Paris. A similar one occurs in Dr. Thomson's edition of the "Elements," and is said to be due to M. Bertrand, of Geneva, and it is also to be found in chapter xv. of De Morgan's "Study and Difficulties of Mathematics," with the remark that it "is more than probable that had the same come down to us sanctioned by the name of Euclid it would have been received without difficulty." E. M. L.

OPTICAL PROJECTION.

Optical Projection. By Lewis Wright. (London: Longmans, Green, and Co., 1891.)

MR. WRIGHT has earned the warm thanks of all teachers and students who use the lantern for lecture or demonstration purposes by this excellent book. It contains about 400 pages. Of these, the first half is devoted to descriptions of the various parts of a lantern, and of apparatus accessory to its use. The principles of projection are clearly explained; then follows an account of the different forms of condensers and their relative advantages. Mr. Wright's criticisms of the various forms are clear and to the point. He recommends, as the one which is generally most useful, two plano-convex lenses with their plane surfaces turned outwards, the lens nearer the radiant being rather the smaller. A discussion of the various forms of objectives comes next, with practical hints for testing both them and the condensers. After this we have several chapters devoted to possible sources of light.

The form of jet for the lime-light which the author recommends is a mixed jet devised by himself, and described on p. 63; this, he says, can sometimes be pushed as bright as 1000 candles; while for the arc light a modification of the Brockie Pell lamp, described on p. 163, seems to have given the most satisfactory results. Full details for using these and other forms of light are given, and the possible sources of danger to which each may give rise are carefully discussed.

The book is throughout thoroughly practical. The best method of preparing the gas, the best form of gas bag, and of pressure boards, the various adjustments required in setting up the burner so as to give the best result, the details of focussing, and many other points, are considered in turn. The best screen appears to be a smooth surface of plaster of Paris, after that a whitewashed wall finished with whitening.

In chapter xii. we have an account of lanterns for special purposes, scientific demonstrations, and the like; among others the elaborate lantern used at the Royal Institution is described.

Considerable space is devoted in chapter xiii. to the projection-microscope, of which the important development in the past ten years is largely due to Mr. Wright.

This concludes the first half of the book. The second part deals with demonstrations in the various branches of natural science. Experiments are described in physics —including heat, light, sound, electricity and magnetism —chemistry, physiology, &c.

With regard to many of these a general criticism may be made. Mr. Wright, in fact, almost suggests it himself on p. 215. There may be occasions on which apparatus and experiments can be shown only by means of projection. The room may be too large and the audience too numerous to permit of the lecture-table being well seen, and the details of an experiment as it is actually performed being followed by all; or, again, a lecturer may have to travel about, as in the case of University Extension lecturers, to various centres; he can fairly easily carry with him slides and small apparatus, whereas it would be impossible to transport all that is required for the performance of the same experiments on a large scale. In such cases as these Mr. Wright's practical details will prove invaluable, but for smaller audiences, or in lecture-rooms attached to permanent laboratories, more will, we think, be learnt from seeing the same experiments performed on a larger scale, rather than with apparatus specially devised to render projection possible.

Another difficulty of a practical kind in the use of the lantern, is that the room must be darkened. Students cannot easily see to make diagrams or take notes; and the lecturer cannot see them, and discover from their faces, as he proceeds, how far he is making himself understood and is interesting the class. However, as was pointed out at the last meeting of the British Association, in an interesting paper by Profs. Barr and Stroud, on the use of the lantern, the room may for many experiments be comparatively bright, provided that the screen is well shaded from the light.

As might be expected from the nature of the case, the section on Optics is the most complete. Mr. Wright's earlier book on "Light" is extremely instructive; the suggestions it contains are in many cases amplified and improved in the present work, and much that is new is added. There is one point, however, on which Mr. Wright does not express his meaning with his usual clearness. He says, when treating of the spectrum (p. 304), that it is in most experiments permissible to converge more light upon the slit by the use of a lens This statement is hardly sufficiently strong: it is not only a permissible course, but also the best course, to form on the slit an image of the source of light, using a lens of such a focal length that all the rays which pass through it, after converging to the slit, diverge so as all to pass through the lens and prism used to form the spectrum. In some cases it may be best to dispense with the condensers and lantern, and merely place the source of light close up to the slit itself. And again, in section 179, the rays emerging from the slit should not be a narrow parallel pencil, but a divergent pencil of such an angle as to fill the lens completely; while in Fig. 171 the light should not be shown as focussed on the prism, but on a screen behind the prism, and at about the same distance as the screen on which the spectrum is formed.

DRY DENUDATION.

Die Denudation in der Wüste und ihre geologische Bedeutung: Untersuchungen über die Bildung der Sedimente in den Ägyptischen Wüsten. Von Johannes Walther, a. o. Professor an der Universität, Jena. (Leipzig: S. Hirzel, 1891.)

THIS book forms the third part (being paged continuously) of the sixteenth volume of the Transactions of the Königlichen Sächsischen Gesellschaft der Wissenschaften. The questions propounded by the author for investigation are the following:—What meteorological forces are active in the deserts? What is their destructive effect on the rocks? What are the ultimate results of this? Is the present sculpturing of the deserts due to the influence of other forces than those which are now active? How can fossil deserts be recognized? The last is left unanswered; the others are considered in the light of information collected from books of travel, and from the author's own studies during two visits to the Egyptian desert.

In regard to rainfall, he points out that no part of the African desert is absolutely rainless, and that, as the storms, though rare, are heavy, the mechanical effects of water are more marked than they would be in a region where precipitation was more uniform. But in a desert, where the absence of plants and of soil exposes the rock to the effects of atmospheric variations, changes of temperature are yet more potent in causing denudation. These changes, owing to the dryness of the air, are great. The diurnal range may be full 30° C., the annual as much as 70° C. By the constant expansion and contraction due to these variations, the rocks are split, and the results are more important in producing denudation than are chemical changes. The author gives a number of illustrations to show how rock-masses in the desert are destroyed by the action of heat and cold, wind, and drifting sand. The surfaces of old walls are corroded; strata of different hardness in the face of a cliff are worn back unequally; masses of rock are isolated, and the blocks and pillars are carved into strange forms; denudation, in short, seems to proceed as actively in a desert as in a damp climate, and along very much the same lines. Isolated hills of tabular form are also very characteristic of desert denudation. These may be either on a large scale—outliers of an extensive plateau—or on a small one, like models, but a few feet high. In each case the cause is the same: a harder stratum at the top has preserved the softer material below. The author also describes the valleys of the desert, usually dry, and the cirques which, as was pointed out some years since by Mr. Jukes Browne (*Geol. Mag.*, Decade 2, vol. iv. p. 477), seem to occur in the deserts of Egypt even as in regions where ice may be supposed to have acted. The description of the latter is important, since it indicates that there is not that necessary connection between glaciers and cirques which some geologists appear to have imagined.

In regard to the excavation of the valleys, and perhaps of some other physical features on a larger scale, we think that the author is disposed to attribute rather too much to the sculpturing effect of heat, cold, and wind (with which of course drifting sand is included), and to overlook the probability that many of the bolder physical features may be memorials of an age when the region was well watered. It is often more than probable that deserts have not always been deserts, but that they are districts of local desiccation, which sometimes may be still in progress. So it is with the Aralo-Caspian area; the Great Salt Lake of Utah and the Dead Sea are mere remnants of fresh-water lakes on a far grander scale. When a large part of the present Jordan valley was one sheet of water, when glaciers replaced the cedars of Lebanon, and the peaks of Sinai were white with perennial snow, the Egyptian desert must have been no longer arid, and permanent streams must have occupied the wadis. Probably since that time the change in the physical features, though doubtless not unimportant, has been in the main superficial; the effects of the arid epoch through which Egypt and some other regions are passing may be compared to those of the Glacial epoch further north. The work has been that of the file rather than of the chisel.

That changes of temperature and the action of drifting sand have been agents of denudation of considerable importance was, of course, well known, and is stated in most text-books of geology, but Prof. Walther has done good service in emphasizing the fact, and in collecting together a number of interesting observations and illustrations which will be useful for reference, especially to teachers.

T. G. B.

OUR BOOK SHELF.

The American Race. By Daniel G. Brinton. (New York: N. D. C. Hodges, 1891.)

By "the American race," Dr. Brinton means the aboriginal race of America, and in the present work he makes what he believes to be the first attempt to classify it systematically on the basis of language. Whether language is, as he contends, "the only basis on which the subdivision of the race should proceed," is a question which needs rather fuller discussion than Dr. Brinton has devoted to it. It may, however, be admitted that in the study of the American aborigines, at the present stage of ethnographical science, no other test works so well upon the whole as the linguistic; and that the results attained by the use of it are interesting and instructive, whether they exactly correspond to racial distinctions, in the strict sense of the expression, or not. Dr. Brinton divides the American race into five great groups—the North Atlantic group, the North Pacific group, the Central group, the South Pacific group, and the South Atlantic group. Taking each of these in turn, he describes the various stocks included in them, paying attention especially to those portions of the continent about which ethnographers are least united. The facts are sometimes presented in a style unnecessarily dry; but the author has taken immense pains to arrange them clearly, and the work will be of genuine value to all who wish to know the substance of what has been found out about the indigenous Americans. We may note that Dr. Brinton does not agree with those who hold that the Red Men originated in America. On the other hand, he sees no reason to suppose that they came from Asia. His theory is, that they were an offshoot from the race which in the earliest times occupied Western Europe, and that they crossed from the one region to the other on a land-bridge. The former existence of this land-bridge he accepts chiefly on the evidence collected by various English geologists.

Charts of the Constellations. By Arthur Cottam, F.R.A.S. (London: Edward Stanford, 1891.)

THE large edition of Mr. Cottam's magnificent charts has met with a well-deserved success, and the smaller edition before us will doubtless be received in a similarly favourable manner. The thirty-six charts in the large edition measure 30 × 22 inches, and were projected on the scale of one-third of an inch to a degree of a great circle; the size in the reduced form is 15 × 12 inches, and the scale is one-half as great. In this handy size the charts will be sure to have a wide circulation among beginners in the study of astronomical science, and to possessors of the smallest telescope with alt-azimuth mounting they are invaluable. The road to an intimate knowledge of the stellar universe is considerably straightened by showing each constellation on a separate chart, whilst three key maps exhibit the relative positions of the various constellations, and will be extremely useful to show alignments over larger spaces than are included on the separate charts. Some notes on the constellations, in conjunction with an excellent introduction explanatory of various astronomical measurements and methods, enhance the value of the charts and help to render the work superior to any hitherto published. G.

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.*]

Co-adaptation.

THE remarks on this subject made by Dr. Romanes (NATURE, March 26, p. 489) do not appear to me to present the case in a fair light, and I therefore think it advisable to make some further observations. In the first place, I do not allow that there is any "fortuity" in the supposition that certain variations, A, B, C, D, &c., may arise in the same individual, for every variation, of whatever kind, must of necessity entail numerous structural and functional modifications. If variations in the length of neck or leg or wing, in the strength of certain muscles, or even in colour, arise "fortuitously" (meaning thereby through some unknown cause antecedent to birth), there must be corresponding variations in the length of the bones, nerves, blood-vessels, &c., as well as in the physiological processes upon which depends the supply of nutriment to the parts in question. If any variation survives, or is perpetuated by breeding, it must therefore possess not only the external visible character A, but also all the concomitant and less obvious or altogether undiscoverable modifications, B, C, D, &c. However complex the correlated modifications may be, the mere existence of the variation implies the existence of such modifications, and the survival of the variation implies the survival of these correlated modifications. If, therefore, it is argued that any variation is a simple case of modification in some one character only—as might be inferred from Dr. Romanes's letter—this is an unwarranted assumption entirely opposed to fact.

But the case we have to consider is that in which the variations A, B, C, D, &c., are not physically or physiologically correlated, but in which they are supposed to be "independent variables." It is to such cases that Mr. Spencer applied his objection. He says ("Factors of Organic Evolution," p. 14):—"What shall we say of co-operative parts which, besides being composed of different tissues, are remote from one another? Not only are we forbidden to assume that they vary together, but we are warranted in asserting that they can have no tendency to vary together. And what are the implications in cases where increase of a structure can be of no service unless there is concomitant increase in many distant structures, which have to join it in performing the action for which it is useful?" Then comes the case of the giraffe, in which Mr. Spencer endeavours to show that the fore- and hind-quarters of this animal must be regarded —if I may venture to express his views briefly—as, "independent variables."

In reply to arguments of this kind, it may be pointed out that mere remoteness does not preclude the possibility of there being correlated variability between structures or functions. And in the next place even if it be admitted that certain parts now co-operative were independently variable at first—as in many cases they no doubt were—it is a gratuitous assumption to suppose that they must have originated from the very beginning in individuals in which the parts were co-operative, *i.e.* in individuals in which the non-correlated variations, "A, B, C, D, &c.," occurred simultaneously. The chances against such variations occurring in any one individual are, I concede most fully, "infinity to one." But if A (with its correlated physical and physiological modifications) survives through natural selection (utility) or is bred by artificial selection, that form is fixed by virtue of its possessing certain characters. If it be said that A cannot exist by itself, but that A + B is the only form capable of existence, then it remains for those who make this assertion to prove that A and B were coincident in time and space *ab initio*. Thus with the giraffe it must be shown that the heightening of the fore-quarters not only conferred no particular advantage, but may even have placed the animal at a disadvantage unless associated with the necessary modifications of the hind-quarters, the necessary modifications being, according to Mr. Spencer, those required to enable the animal to escape pursuit, "since any failure in the adjustment of their respective strengths [the fore- and hind-quarters] would entail some defect in speed and consequent loss of life when chased." To me—and I speak with all deference to the views of Mr. Spencer—this seems like an imposition on Nature of certain conditions which might not be true. It cannot be dogmatically laid down that at the time of its development from the ancestral form the necessity for escaping pursuit was of equal or greater importance than the faculty of high-reaching. In fact, the heightening of the fore-quarters is just as likely to have *diminished* the necessity for great speed, by enabling the animal to take a wider survey of its surroundings, and so to get sight of its enemies in time to escape. But, if speed were essential for the preservation of the species, I must confess that I see no difficulty in the belief that this character also might be superadded subsequently to the heightened fore-quarters in the same way that other associations of characters arising from "independent variables" are fixed by artificial selection. I do not admit therefore that "all this is quite wide of the mark"; on the contrary, I believe that it is *the* mark, and that the particular case of co-adaptation quoted by Mr. Pascoe (I am afraid in a somewhat garbled form) may resolve itself into a "confluence of adaptations." In fact, I do not think that it would be going too far to put forward the proposition that all cases of co-adaptation may be ultimately explained in the same way, *i.e.* that they arise from the coalescence (by intercrossing) of *n* modifications each *useful* (not useless) in itself, and acquired at successive periods in the phylogeny of the race.

The remarks with which I have endeavoured to meet the arguments advanced by Dr. Romanes ignore the "difficulty" which he have interposed with respect to the want of analogy between artificial and natural selection. I have left this out of consideration advisedly, because it raises one of the questions which have so long divided Dr. Romanes from those whom he has thought proper to label "neo-Darwinians." It is the old difficulty of "the swamping effects of intercrossing" under another form. I do not believe in the reality of this difficulty, and it has been so amply treated of by Dr. Wallace and others that I do not feel warranted in trespassing upon these columns at any greater length in order to rediscuss the question. I can only assure those who have read the comments made upon my review of Mr. Pascoe's book that I have not been made the subject of any metaphorical fraud, but that I accept the analogy between artificial and natural selection as real.

R. Meldola.

The Meaning of Algebraic Symbols in Applied Mathematics.

Dr. Lodge's remarks on p. 513 (April 2), ought not, I think, to pass without protest. He very reasonably objects to being asked to use a formula which is adapted to one particular set of units, and is not convenient for any other set, and prefers the greater freedom which is usually indulged in, as regards units, in mathematical physics. But he goes further than this, and maintains that it is best (he almost suggests that it is necessary) that Prof. Greenhill's practical man, if he wishes to avoid the somewhat mild difficulties which at present beset him, should adopt the system set forth in Nature, vol. xxxviii. p. 281. It may be a reasonable thing to do to base the interpretation of physical equations upon the method of multiplication of concrete quantities described in the article referred to; but that the practical man, whose difficulties are in question, is likely to take the trouble to understand it, may be confidently denied.

However, I think that the system of interpretation advocated involves other inconveniences. Suppose, for some purpose, we chose to measure the velocity of light by the distance of the light of that colour from a given line in a standard spectrum, thus giving velocity for this purpose the dimension length. This quantity would have different properties from the same velocity measured in the usual way; it would practically be a different quantity; yet the velocity of light is independent of the mode adopted for measuring it. Does it not make confusion to insist upon one of these two quantities being the concrete velocity itself, some other name having to be invented for the other? The same confusion of language would arise even if we desired to depart so slightly from the usual practice as to use our velocity symbol for the specification of it in miles per second, using a centimetre for the unit of length.

I have found that, occasionally, a good way of clearing up difficulties of pupils about dimensions is to say that it is no more intrinsically absurd to equate an area to a length than to equate a length to a product of a velocity and a time, all the symbols being numbers; but that the latter equation can be employed without abandoning the particular freedom as to subsequent choice of units which we wish to retain, and that the former cannot. I have heard a lecturer appeal, in a similar case, to the intrinsic absurdity of saying that the area of a field is equal to the distance from here to London: this appears to me to be not so clear a way of talking of the distinction between the two cases.

Finally, what are the disadvantages of considering the symbols of quantity to be mere numbers? Dr. Lodge, while making out his case as against Prof. Greenhill, is, to my mind, quite unconvincing on this more general point.

King's College, Cambridge, April 11. W. H. Macaulay.

Force and Determinism.

Dr. Oliver J. Lodge has reminded us, in your issue of March 26 (p. 491), that under physical constraint or control the direction of motion of material particles may be changed without expenditure of energy or performance of work.

It does not follow from this that the direction of motion can be changed under psychical control or constraint—that is to say, by life, mind, will-power.

If mind controls the motion of molecules, then mind must either be reckoned among the physical forces, differing, however, from all other modes of physical force in that it always acts at right angles to motion; or else energy must be regarded as *meta*physically determined.

It is right that your readers should be informed that there are many philosophers (I allude especially to those who accept the hypothesis of scientific monism) who regard the supposed control of mind over matter, or of matter over mind, as an assumption which is unnecessary and unsatisfactory.

An arbitrary alteration of the weather might involve no contradiction of the principle of the conservation of energy, and yet at the same time completely upset our notions of physical causation by the introduction of metaphysical interference.

If the distinction between generating motion and directing motion is one useful to remember, that betwen physical and metaphysical control is still more important.

University College, Bristol. C. Lloyd Morgan.

The Influence of Temperature on the Vagus.

In Nature of April 9 (p. 548) I notice that Dr. G. N. Stewart says: "nor has the influence of temperature on the vagus been before studied by a suitable graphic method." It appears to me that this sweeping assertion is not in accordance with facts, for in my paper upon the "Influence of Temperature on the Pulsations of the Mammalian Heart and on the Action of the Vagus," published in the St. Bartholomew's Hospital Reports for 1871, p. 216, I described a graphic method invented by Prof. Stricker, of Vienna, and employed by me with very satisfactory results. The apparatus may have been ruder than that employed by Dr. Stewart, but the tracings obtained by it were sharp and clear, and allowed the beats of the heart to be easily counted, even when the pulse rate was 470 per minute. The important fact that the peripheral ends of the vagus are not paralyzed by heat, but retain their power to the last, was clearly demonstrated in this paper. T. Lauder Brunton.

Antipathy of Birds for Colour.

At this season the yellow crocus is coming up, and again being destroyed, either playfully or maliciously, by the house sparrow. Has the bird an aversion to yellow? This could be tested by throwing bits of coloured wool about, and finding what colours are used in nesting. I should be glad to learn if this has been tried, and the result. M. H. M.

April 13.

The Discovery of Comet *a* 1891.

It is stated that Prof. Barnard, of the Lick Observatory, Mount Hamilton, anticipated me in the discovery of comet *a* 1891, as he first saw the comet on the evening of March 29, whereas my observation was made on March 30. My information on the point is somewhat meagre and uncertain, but it is very likely to prove correct. If so, I must relinquish my claim to priority, and comfort myself with the reflection that my discovery was an independent one, and that it conveyed the first notification of the comet received by the chief Observatories of Europe.

The *Times* of April 1 published a telegraphic message, dated Mount Hamilton, March 31, as follows:—

"A small but fairly bright comet, with a tail of 15 minutes in length, was discovered by Prof. Barnard at 8.34 on Tuesday night at the Lick Observatory, the position being right ascension one hour ten minutes and ten seconds, north declination 44 degrees 48 minutes, moving rapidly southwards in the direction of the sun at the rate of one degree per day."

Now this telegram, if correct, would show that Prof. Barnard's discovery followed, not preceded, my own (made at 9h. on Monday night, March 30), and several scientific journals have alluded to the matter on the basis of the paragraph above quoted. But I think it highly probable the *Times'* telegram contained several inaccuracies, and that Prof. Barnard first saw the comet on Sunday night, March 29. Further particulars from America will no doubt shortly come to hand. If Prof. Barnard is entitled to priority, let it be freely accorded to him, and he will have my sincere congratulations on another success in a field where he has previously earned such high distinction.

Bristol, April 11. W. F. Denning.

ON SOME POINTS IN THE EARLY HISTORY OF ASTRONOMY.[1]

I.

IN the last astronomical course given in this theatre the subject touched upon was our present knowledge of the sun and stars. Some of you may possibly have been present at the lectures, but in any case the point made was something like this: an enormous advance had recently been made in our astronomical knowledge and in our powers of investigating the various bodies which people space, by the introduction of methods of work and ideas from other branches of science: the purpose was to show that the recent progress was to a large extent dependent upon the introduction of methods from other sciences.

The present course will also deal with the sun and stars, but the point of view will be changed. What I shall endeavour to do in the present course will be to show that a knowledge of even elementary astronomy may be of very great assistance to students of other branches of science; in other words, that astronomy is well able to pay her debt. Those branches to which I shall now chiefly refer are archæology, history, folk-lore, and all that learning which deals with man's first attempts to grasp the meaning and phenomena of the universe in which he found himself before any scientific methods were available to him, before he had any idea of the origins or the conditionings of the things around him. You can quite understand that for that we have to go a considerable distance back in time.

It seems to be generally accepted by archæologists that the first civilizations with which we are acquainted were those in the Nile valley and in the adjacent countries.

The information which we possess concerning these countries has been obtained from the remains of their cities, of their temples, even of their observatories and of the records of their observatories: of history on papyrus we have relatively little.

But when we come to the other two groups of nations to which I shall have to refer, China and India, there we have paper records; but, alas, no monuments of undoubtedly high antiquity. It is true that there are many monuments in India in the present day, but, on the authority of Prof. Max Müller, these monuments are relatively modern. We go back in Egypt to a period, as estimated by various authors, of something like 6000 or 7000 years; we go back in Babylonia certainly 4000 years; in China and in India we go back as certainly to more than 4000 years ago.

When one comes to examine the texts, whether written on papyrus, burnt in brick, or cut on stone, which archæologists have obtained from these sources, we at once realize that man's earliest observations of the heavenly bodies may very fairly be divided into three perfectly distinct stages; I do not mean to say that these stages follow each other exactly, but at one period one stage was more developed than another, and so on.

For instance, in the first stage, wonder and worship were the prevalent features; in the second, there was a desire to apply the observation of celestial phenomena in two directions, one the astrological direction, and the other, the direction of utility—for instance, the formation of a calendar and the foundation of years and months and days.

[1] From shorthand notes of a course of lectures to working men delivered at the Museum of Practical Geology, Jermyn Street, in November 1890. The notes were revised by me at Aswan during the month of January. I have found, since my return from Egypt in March, that part of the subject-matter of the lectures has been previously discussed by Herr Nissen, who has employed the same materials as myself. To him, therefore, so far as I at present know, belongs the credit of having first made the suggestion that ancient temples were oriented on an astronomical basis. His article is to be found in the *Rheinisches Museum für Philologie*, 1885.

Only more recently—not at all apparently in the early stage—was any observation made of any celestial object for the mere purpose of getting knowledge. We know from the recent discoveries of Strassmaier and Epping that this stage was reached at Babylon at least 300 years B.C., at which period regular calculations were made of the *future* positions of moon and planets. This of course is now practically the only source of interest in astronomy to us: we no longer worship the sun; we no longer believe in astrology; we have our calendar; but we must have a nautical almanac calculated years beforehand, and some of us like to know a little about the universe which surrounds us.

It is very curious and interesting to know that this first stage, this stage of worship, is practically missing in the Chinese annals; the very earliest Chinese observations show us the Chinese, a thoroughly practical people, trying to get as much out of the stars as they could for their terrestrial purposes.

In Assyria and Babylonia it is a remarkable thing that from the beginning of things—so far as we can judge from the monuments—the sign for God was a star; and although the information is perhaps not so precise as in the case of Egypt, yet no doubt in Babylonia the worship stage existed in equal activity.

We may take the Vedas to bring before us the remnants of the first ideas which dawned upon the minds of the earliest dwellers in Western Asia—that is, the territory comprised between the Mediterranean, the Black Sea, the Caucasus, the Caspian Sea, the Indus, and the waters which bound the southern coasts, say, as far as Cape Comorin. Of these populations, probably the Chaldæans may be reckoned as being the first. According to Lenormant—and he is followed by all the best scholars—this region was invaded in the earliest times by peoples coming from the steppes of Northern Asia. Bit by bit they spread to the west and east. There are strange variants in the ideas of the Chaldæans recovered from the monuments and those preserved in the Vedas. Nevertheless, we find a sun-god—Utu, Babbar[1]—and the following hymn:—

> "Oh Sun, in the most profound heaven thou shinest. Thou openest the locks which close the high heavens. Thou openest the door of heaven. Oh Sun, towards the surface of the earth thou turnest thy face. Oh Sun, thou spreadest above the surface, like a mantle, the splendour of heaven."

The earth to these peoples was a round boat, bottom-uppermost, surrounded on all sides by ocean (Apsu) near the edge; on the edge itself rested the hemispherical sky (Anna). As the sky thus rested on the earth, the earth rested on an abyss, the home of death and darkness.

Let us consider for a moment what were the first conditions under which the stars and the sun would be observed. There was no knowledge, but we can very well understand that there was much awe, and fear, and wonder. Man then possessed no instruments, and the eyes and the minds of the early observers were absolutely untrained. Further, night to them seemed almost death, no man could work; for them, there was no electric light, to say nothing of candles, so that in the absence of the moon the night reigned like death over every land. There is no necessity for us to go far into this matter by trying to put ourselves into the places of these early peoples; we have only to look at the records: they speak very clearly for themselves.

Let us begin with India, whence the first complete revelations of this kind came. Max Müller and others during recent years have brought before us an immense amount of most interesting information, some of which I hope now is to be found in our free libraries.

They tell us that 1500 years B.C. there was a ritual, a set of hymns called the Veda (Veda meaning knowledge).

[1] Maspéro, "Histoire ancienne des Peuples de l'Orient," p. 136.

These hymns were written in Sanskrit, which a few years ago was almost an unknown language; we know now that it turns out to be the nearest relation to our English tongue. The thoughts and feelings expressed in these early hymns contain the first roots and germs of that intellectual growth which connects our own generation with the ancestors of the Aryan races; "those very people who, as we now learn from the Vedas, at the rising and the setting of the sun listened with trembling hearts to the sacred songs chanted by their priests. The Veda, in fact, is the oldest book in which we can study the first beginnings of our language and of everything which is embodied in all the languages under the sun." The oldest, most primitive, most simple form of Aryan Nature-worship finds expression in this wonderful hymnal, which doubtless brings before us the rituals of the ancient Aryan populations represented also by the Medes and Persians. There was, however, another branch, represented by the Zend-Avesta, as opposed to the Vedas, among whom there was a more or less conscious opposition to the gods of Nature, to which we are about to refer, and a striving after a more spiritual deity, proclaimed by Zoroaster under the name of Ahura-Mazda, or Ormuzd. The existence of these rituals side by side in time tends to throw back the origin of the Nature-worship of both. Now, what do we find? In the Veda the gods are called Devas, a word which means bright; brightness or light being one of the most general attributes shared by the various manifestations of the deity. What were the deities? The sun, the sky, the dawn, fire, and storm. It is clear, in fact, from the Vedas that sunrise was, to those from whom the ritual had been derived, the great revelation of Nature, and in time in the minds of the poets of the Veda, "deva," from meaning "bright," gradually came to mean "divine." Sunrise it was that inspired the first prayers of our race, and called forth the first sacrificial flames. Here, for instance, is an extract from one of the Vedas. "Will the sun rise again? Will our old friend the Dawn come back again? Will the power of Darkness be conquered by the God of Light?"

These three questions in one hymn will show what a questionable stage in man's history is thus brought before us. We find very many names for Sun-gods—

Mitra,
Indra (the day brought by the sun),
Sûrya,
Vasishtha,
Arusha (bright or red);

and for the Dawn-gods—

Ushas,
Dyaus,
Dyotanâ,
Ahanâ,
Urvasî,

We have only to consider how tremendously important must have been the coming of the sun in the morning, bringing everything with it, and the dying away of the sun in the evening, followed at once by semi-tropical quick darkness, to cease to wonder at such worship as this. Here is an extract from one hymn to the Dawn (Ushas):—

(1) She shines upon us like a young wife rousing every living being to go to his work; when the fire had to be kindled by men she made the light by striking down darkness.

(2) She rose up spreading far and wide, and moving everywhere, she grew in brightness, wearing her brilliant garment [the mother of the cows (the mornings)], the leader of the days, she shone gold-coloured, lovely to behold.

(3) She, the fortunate, who brings the eye of the gods, who leads the white and lovely steed (of the sun), the *Dawn*, was seen revealed by her rays, with brilliant treasures, following everyone.

(4) Thou art a blessing when thou art near. . . . Raise up wealth to the worshipper, thou mighty *Dawn*.

(5) Shine for us with thy best rays, thou bright Dawn. . . .

(6) Thou daughter of the sky, thou high-born Dawn. . . .

In addition to the Sun and the Dawn, which turn out to be the two great deities in the early Indian Pantheon, other gods are to be met with, such as Prithivî, the Earth on which we dwell; Varuna, the Sky; Ap, the Waters; Agni, the Fire; and Maruts, the Storm-gods. Of these, Varuna is especially interesting to us. We read:—

"Varuna stemmed asunder the wide firmament; he lifted up on high the bright and glorious heaven; he stretched out apart the starry sky and the earth."

Again—

"This earth, too, belongs to Varuna, the king, and this wide sky with its ends far apart. The two seas (the sky and the ocean) are Varuna's loins."

Finally, the result of all this astral worship was to give an idea of the connection between the earth and the sun and the heavens, which are illustrated in later Indian pictures, which bring before us modernized and much more concrete views of these early notions, ultimately transformed into this piece of poetic thought—that the earth was a shell supported by elephants which represent strength, the elephants being supported on a tortoise which represents infinite slowness.

This poetical view subsequently gave way to one less poetical—namely, that the earth was supported by pillars; on what the pillars rested is not stated, and it does not matter. We must not consider this as ridiculous, and pardonable merely because it is so early in point of time, because, coming to the time of Greek civilization, Anaximander told us that the earth was cylindrical in shape, and every place that was then known was situated on the flat end of the cylinder; and Plato, on the ground that the cube was the most perfect geometrical figure, imagined the earth to be a cube, the part of the earth known to the Greeks being on the upper surface. In these matters, indeed, the vaunted Greek mind was little in advance of the predecessors of the Vedic priests.

We now turn to Egypt. Here, as I have said, the main source of information consists no longer in writings like the Vedas, but in the inscriptions on the monuments. It is true that, in addition to the monuments, we have the Book of the Dead, and certain records found in tombs; but, in the main, the source of information which has been most largely drawn upon consists in the monuments themselves.

It has been impossible, up to the present time, to fix with very great accuracy the date of the earliest monuments. If any of you will get from your public libraries any books on Egypt, I am sure you will feel that it is not a question of knowing so little—it is a question of knowing anything at all. When one considers that at the beginning of this century not a sign on any of these monuments was understood, and that now the wonderful genius of a small number of students has enabled Egyptologists to read the inscriptions with almost as much ease and certainty as we read our morning papers; *this* is what is surprising, and not the fact that we as yet know so little, and in many cases lack certainty.

I have told you that probably some of these monuments are 6000 or 7000 years old. How has this been determined? One of the many points investigated by Egyptologists has been the chronology of the kings of Egypt from their first king, whom all students recognize as Mena or Menes. All these students have come to the definite conclusion that there was a King Menes, and that he reigned a long time ago; but with all their skill the total result is that they cannot agree to the date of this king within a thousand years, for the reason that in these early days astronomy was a science still to be cultivated, and therefore the early Egyptians had not a perfect mode of recording; they had no idea of a hundred years as we have. All their reckonings were the reckonings of the reigns of kings. We now, fortunately for us, have a calendar which enables us to deal with large intervals of time, but still we reckon, in Egyptian fashion, by the reigns of kings in our Acts of Parliament. Furthermore, Egypt being then a country liable to devastating wars, and to the temporary supremacy of different kingly tribes, it has been very difficult to disentangle the various lists of kings so as to obtain one chronological line, for the reason that sometimes there were lines of kings existing together in different regions. The latest date for King Menes is, according to Bunsen, 3600 years B.C.; the earliest date, assigned by Boeckh, 5702 years B.C.; Unger, Brugsch, and Lepsius give, respectively, 5613, 4455, 3892. For our purpose we will call the date 4000 B.C.—that is, 6000 years ago.

We come now to deal with the ideas of the early inhabitants of the Nile valley. We find that in Egypt, as in India, we are in presence absolutely of the worship of the Sun and of the accompanying Dawn. The early Egyptians, whether they were separate from, or more or less allied in their origin to, the early Chaldæans, had exactly the same view of Nature-worship as the others had, and we find in their hymns and the lists of their gods that the Dawn and the Sunrise were the great revelations of Nature, and the things which were most important to man; *and therefore everything connected with the Sunrise and the Dawn was worshipped.*

Renouf, one of the most competent of living writers on these subjects, says: "I fear Egyptologists will soon be accused, like other persons, of seeing the dawn everywhere," and he quotes with approbation, and applies to his own subject, the following passage from Max Müller relating to the Veda:—

"I look upon the sunrise and sunset, on the daily return of day and night, on the battle between light and darkness, on the whole solar drama in all its details, that is acted every day, every month, every year, in heaven and in earth, as the principal subject."

Among the names given by the Egyptians to the sun are:—

Hor, or Horus.
Chepera (morning sun).
Rā (noon).
Tmu (evening sun).
Osiris (sun when set).

The phenomena of morning and evening twilight gave rise to the following divinities:—

Isis represents the Dawn and the Twilight; she prepares the way for the Sun-god. The rising sun between Isis and Nephthys = morning.

Nephthys is the Dawn and the Twilight, sometimes Sunset.

Shu is also the Dawn, or sunlight. Tefnut represents the coloured rays at dawn. Shu and Tefnut are the eyes of Horus. Shu was also called "Neshem," which means green felspar, in consequence of the green colour observed at dawn. The green tint at dawn and sunset are represented further by the "sycamore of emerald." Sechet is another goddess of the Dawn, the fiery Dawn.

The *red* colours at sunset were said to be caused by the blood flowing from the Sun-god when he hastens to his suicide. A legend describes Isis as stanching the blood flowing from the wound inflicted on Horus by Set.

Hathor is, according to Budge, identified with Nu or Nut, the sky, or place in which she brought forth and suckled Horus. She is the female power of Nature, and has some of the attributes of Isis, Nut, and Maāt.

I have not time to quote the many hymns to the Sun-gods which have been recovered from the inscriptions, but the following extracts will show that the worship was in the main at sunrise or sunset—in other words, that the *horizon* was in question:—

"Thou disk of the Sun, thou living God! There is none other beside thee. Thou givest health to the eyes through thy beams, Creator of all beings. *Thou goest up on the eastern horizon of the heaven* to dispense life to all which thou hast created—to man, four-footed beasts, birds, and all manner of creeping things on the earth where they live. Thus they behold thee, and they go to sleep when thou settest."

Hymn to Tmu—

"Come to me, O thou Sun,
Horus of the horizon, give me help."

Hymn to Horus—

"O Horus of the horizon, there is none other beside thee,
Protector of millions, deliverer of tens of thousands."

Hymn to Ra-Tmu-Horus—

"Hail to thee of the double horizon, the one god living by Maat. . . . I am the maker of heaven and of the mysteries of the twofold horizon."

Hymn to Osiris—

"O Osiris! Thou art the youth *at the horizon* of heaven daily, and thine old age at the beginning of all seasons. . . .

"The *ever-moving* stars are under obedience to him, and so are *the stars which set.*"

Hymn to Ra—

"O Ra! in thine egg, radiant in thy disk, shining forth from the horizon, swimming over the steel (?) firmament.

"Tmu and Horus of the horizon pay homage to thee (Amon-Ra) in all their words."

We next have to gain some general idea of the Egyptian cosmogony—the relation of the sun and dawn to the sky; this is very different from the Indian view. The Sky is Nu (Fig. 1), represented as a female figure bending over Seb, the Earth, with her feet on one and her finger-tips on the other horizon. The Sun-gods, and even the stars, were supposed to travel in boats across the firmament from one horizon to the other. The underworld was the abode of the dead, and daily the sun and the stars which set died on passing to the regions of the west, or Amenti, below the western horizon, to be born again on the eastern horizon on the morrow. In this we have the germ of the Egyptian idea of immortality.

Among other gods which may be mentioned are Chnemu, the "Moulder," who was thought to possess some of the attributes of Rā; and Patah (or Ptah), the "Opener," who is at times represented with Isis and Nephthys, and then appears as a form of Osiris.

We can now begin to glimpse the Egyptian mythology. Seb, the Earth, was the husband of Nut, the Sky; and the Sun- and Dawn-gods and goddesses were their children, as also were Shu, representing sunlight, and Tefnut, representing the flames of dawn.

Maāt, the goddess of law, was the daughter of Ra.

When one comes to consider the Rig-Veda and the Egyptian monuments from an astronomical point of view, one is struck by the fact that the early worship and all the early observations related to the horizon. This was true not only for the sun, with which so far we have exclusively dealt, but it was equally true of the stars which studded the general expanse of sky.

We must be perfectly clear before we go further what this horizon really is, and for this some diagrams are necessary.

The horizon of any place is the circle which bounds our view of the earth's surface, along which the land (or sea) and sky appear to meet. We have to consider the relation of the horizon of any place to the apparent movements of celestial bodies at that place.

We know, by means of the demonstration afforded by Foucault's pendulum, that the earth rotates on its axis, but this idea was of course quite foreign to these early peoples. Since the earth rotates with stars, infinitely removed, surrounding it on all sides, the apparent movements of the stars will depend very much upon the position we happen to occupy on the earth: this can be made quite clear by these diagrams. An observer at the North Pole of the earth, for instance, would see the stars moving round in circles

FIG. 1.—Egyptian representation of the Earth (Seb), a recumbent figure; with Nu stretching over the Earth from horizon to horizon, and the boats of the Sun-gods floating over her.

parallel to the horizon. No star would either rise or set—one half of the heavens would be always visible above his horizon, and the other half invisible; whereas

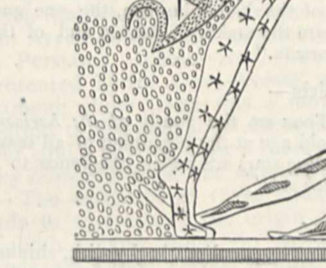

FIG. 2.—The celestial sphere, as viewed from the North Pole. A parallel sphere.

an observer at the South Pole would see that half of the stars invisible to the observer at the northern one, because it was the half below his horizon. If the

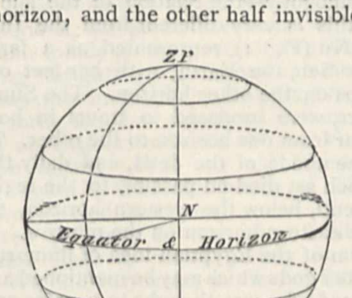

FIG. 3.—The celestial sphere, as viewed from the Equator. A right sphere.

observer be on the equator, the movements of the stars will appear to be as indicated in this diagram (Fig. 3)—that is, all the stars will rise and set, and each star in turn will be half its time above the horizon, and half its time below it. But if we consider the position of an observer in middle latitude, say in London, we find that some stars will always be above the horizon, some always below—that is, they will neither rise nor set. All other stars will both rise and set, but some of them will be above the horizon for a long time and below for a short time, whereas others will be a very short time above the horizon and a long time below it.

Wherever we are upon the earth we always imagine that we are on the top of it. The idea held by all

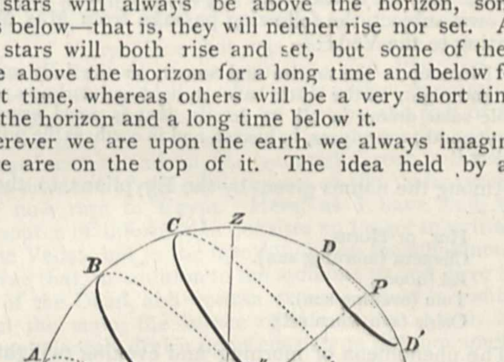

FIG. 4.—The celestial sphere, viewed from a middle latitude. An oblique sphere. In this woodcut DD' shows the apparent path of a circumpolar star; BB'B'' the path and rising and setting points of an equatorial star; CC'C'' and AA'A'' those of stars of mid declination, one north and the other south.

the early peoples was that the earth was an extended plain: they imagined that the land that they knew and just the surrounding lands were really in the centre of the extended plain. Plato, for instance, was content to put the Mediterranean and Greece upon the top of his cube, and Anaximander placed the same region at the top of his cylinder.

By the use of the globe we can best study the conditions of observation at the poles of the earth, the equator, and some place in middle latitude. The wooden horizon of the globe is parallel to the horizon of a place

FIG. 5.—Diagram to show how the inclination of the horizon of London will change with the rotation of the Earth.

at the top of the globe, which horizon we can represent by a wafer. In this way we can get a very concrete idea of the different relations of the observer's horizon to the apparent paths of the stars in different latitudes.

J. NORMAN LOCKYER.

(*To be continued.*)

ADDITIONAL RESULTS OF THE UNITED STATES SCIENTIFIC EXPEDITION TO WEST AFRICA.

WRITING a year ago from Ascension Island, I gave to NATURE a partial account of the work of the Expedition from October 1889 to March 1890. Subsequently the U.S.S. *Pensacola*, Captain A. R. Yates, U.S. Navy, commanding, arrived at Barbados on April 28, at Bermuda on May 18, and terminated her cruise with the Expedition on reaching New York on the 23rd of the same month.

My previous communication to NATURE (vol. xlii. p. 8), relates the great obligation of the Expedition to His Excellency Governor Sir H. B. Loch, and to Dr. David Gill, H.M. Astronomer at Cape Town, to His Excellency Governor Antrobus, at Saint Helena, and to Captain Napier, R.N., then in charge of Ascension, acting in accordance with the very liberal instructions of the Admiralty. Although our arrival at Barbados was entirely unexpected, all necessary facilities were at once provided by direction of His Excellency Governor Sir Walter Sendall.

The gravity and magnetic work at Bridgetown occupied nearly a fortnight. Mr. E. D. Preston, in special charge of this department of the Expedition, occupied in all fourteen magnetic stations, of which five were on the West Coast of Africa, and eight on islands of the North and South Atlantic. The area of the gravity stations extends from Cape Town to Washington, covering a range of 73° in latitude, and 96° in longitude. The elevations of these stations range from 7 feet to 2250 feet above sea-level. These observations are now in progress of reduction by Mr. Preston, under the direction of Prof. Mendenhall, Superintendent of the U.S. Coast and Geodetic Survey; and the definitive results will, it is hoped, be available at the conclusion of the present year. "Whether," says Mr. Preston, "they show the Atlantic islands to be heavy or light as compared with the continental masses, they will at least add considerable new material for the determination of the earth's figure."

By direction of the Hon. Secretary of War, and General Greely, Chief Signal Officer of the Army, Prof. Cleveland Abbe was detailed as meteorologist of the Expedition. His observations and researches, assiduously conducted during the entire cruise of the *Pensacola*, are so significant that no brief statement can do them full justice. From the forthcoming Report of the Expedition I excerpt the following sections of Prof. Abbe's preliminary report:—

(1) I should mention at the outset that the work with small balloons was carried on sufficiently to demonstrate the practicability of this method of getting the actual velocity of the wind; but, by the advice of the maker of the balloons, I had omitted taking up with me the varnish ordinarily used, as being probably unnecessary and possibly dangerous to manipulate on ship-board. The result was that I found it would become necessary to use more balloons than originally contemplated. Still I deem it a decided gain to have been able to make enough observations to show that the method of determining the velocity of the wind by small balloons is accurate and practicable, both on land and sea, and but little, if at all, more expensive than the use of self-recording anemometers.

(2) The mirror nephoscope used by me rested on the Ritchie liquid compass (U.S. Navy standard), which was established on the after-bridge, and which compass I was free to use at all times. Although free in its gimbals, yet the compass is by no means exactly horizontal; so that more numerous observations must be made at sea than on land, if the same resulting accuracy is desired. I was able to maintain daily observations, and I can but consider that the opportunity thus offered me has been entirely unique in the history of meteorology; and unless I am greatly mistaken in my knowledge of the literature of the subject, it will be found that the results attained will form a valuable basis for further study. My observations have in fact led to some change in my own views as to the general circulation of the atmosphere, and every form of fluid motion has been found by me to be visibly illustrated in the cloud-structure.

(3) I have attempted a simple and rational classification of clouds, based, not on shapes and appearances, but primarily on their modes of formation.

(4) A method of using the nephoscope has been elaborated for the determination of actual heights and velocities of clouds (or balloons) by combining observations made when the observer is moving successively in two different directions, or with two different velocities. The instrument can be used in a waggon, or car, or boat. I call this "*the aberration method*," as distinguished from ordinary parallax methods.

(5) My work shows that the observed movements of the clouds and the wind have such a relation to the presence of a storm centre, an island, or to any other disturbance, that one should be able to locate the position of such a disturbance by observations made at one locality.

(6) At Fayal, on the summit of Pico, I first observed the formation of a cloud, with which I afterwards became

familiar in other similar localities, and which must be well known in mountainous countries. Although not often clearly described, this is a slender white stream, which is sometimes likened to a table-cloth or to a soft hood. It has nothing of the boiling vertical motion characteristic of the cumulus; nothing of the curling and rolling motions characteristic of the scud-cloud. It is a smooth stream, of soft appearance, of very gentle curvature, and illustrates an elementary form of fluid motion. It is the simplest cloud that can be formed by the slow steady rise and fall of undulating streams of air. As seen from Fayal, this cloud marked the lowest limit at which the densest cirrus could form in an atmosphere having the temperature and moisture then prevailing. When a mountain obstructs the lower wind, it forms a scud-cumulus, or cumulus whose ascending currents are due to obstructed wind rather than to internal heat. These cumuli themselves obstruct the wind prevailing at their own higher levels. The latter is therefore pushed up, but it rises slowly and smoothly, being a case of "steady motion" without forming discontinuous eddies; and thus generates the smooth white hood, or arched crescent cloud.

The hood will form on the peak itself if the air below the summit is calm, so that scud-cumuli do not form by reason of horizontal winds, or if the lower air be cold or dry and dense, so that the cumuli will not form by reason of heat. In such cases the summit of the peak can itself be considered as a small obstacle to the gentle current at its level. When large cumuli form in open regions, their summits then become like the mountain, comparatively small obstacles to the upper current; and, under these circumstances, beautiful hoods form in the warm moist air ascending on the sunny sides of the cumuli. For the formation of these, it is simply necessary that the upward deflection of the disturbed horizontal motion of the upper current shall be so gentle as not to introduce sudden curves and eddies. Even without the formation of a visible cumulus there may be a large invisible mass of rising air, not yet cooled to saturation; and in such a case the crescent hood may even be seen to form in mid-air, and the cumulus may subsequently become visible. At Green Mountain, on the Island of Ascension, the heavy south-east trade strikes an abrupt surface, and is thrown up to a great height, whence it descends; and, like a standing wave in the river, flows off many miles to leeward. Several times I was able to observe the crescent cloud forming in mid-air in a clear blue sky for a short space only, and evidently at the very summit of the first of these standing waves. On Table Mountain, at Cape Town, the so-called "table-cloth" was, at least during our visit, a mass of rolling scud-cumuli; but above these there were occasionally to be seen small beautiful crescent hoods.

(7) At Freetown, Sierra Leone, the study of two arched squalls showed, as I expected, that they and the African tornado and the afternoon thunderstorms of the eastern coast of the United States are the same in nature and laws, differing only in degree.

(8) At Elmina the study of the Harmattan wind, through which we had been passing for several days, was combined with notes made by a good observer on shore, showing unmistakably that this is a mass of dry, and therefore dense, air flowing from the interior of Northern Africa at this season. It brings with it the fine white ashes due to innumerable local bush-fires in the interior, commonly called "dust from the desert"; and the whole phenomenon is analogous to the flow of dry, cold air from Canada, south-eastward over the United States, making our so-called "north-westers." The Bora of Russia and the Pampero of South America have a similar physical origin.

(9) At Cape Ledo I found the finest imaginable opportunity to study the formation of the overflow from the summit of the cumulus clouds, and its gradual transformation into slowly-dissolving stratus. It was a daily phenomenon at Cape Ledo to observe the large cumuli ascend bodily, lose their flat bottoms, become pear- or balloon-shaped, and then spread out into fields of most beautiful spots, vortices, striæ, curds, and other forms. The "mackerel sky" did not occur at this time. The motion of the lower cumuli was with the lower south-west winds; but the overflow into the stratus and cirrus moved from the east in the afternoons out westward over the sea. But if these clouds endured over night, as they usually did, then in the morning they were found to have descended, and to be moving from the west toward the land; while below them the cool, easterly land breeze existed for a few hours with a slight scud or cloud-rip on its upper surface.

(10) At Cape Town we experienced an unusually heavy south-easter. There had also been a remarkably destructive north-westerly storm in the previous July. I made detailed maps illustrating the south-easter, and obtained from Mr. A. G. Howard his own maps illustrating the storm of July, all based on the data of the Meteorological Commission for South Africa. These maps were made the basis of an address to the South African Philosophical Society on the practicability of storm warnings, and I think it may safely be anticipated that within a few years there will be such a system in active operation at all the ports on the South African coast. The remarkable development of rare and beautiful flowers over the whole of Table Mountain is, of course, possible only by virtue of the damp atmosphere and the steady drip of fog-particles from leaves and rocks, quite as much as by virtue of the rainfall, as ordinarily measured.

(11) At Saint Helena my attention was attracted first of all to the matter of rainfall. A previous study of the subject had convinced me that the local temperature of the air over the land could have little or nothing to do with the rainfall in a small isolated tropical island; that the extraction of the moisture as rain from the air must be done in cumuli that are formed by the impinging of the trade-wind upon the island as an obstacle to its progress, and not in cumuli carried up by heat of an overheated land-surface; and that therefore the rainfall of Saint Helena was a direct indication of the average wind striking against the island, since the moisture is so uniform. I consider the Saint Helena rainfall as the best index to the average movement of the air, and as depending therefore, like the movement of the air, on the meteorological conditions over a large surface of the ocean. Similar considerations apply to other islands, as Ascension and Barbados, at both of which I have therefore made the rainfall a matter of special solicitude. At Saint Helena my attention was attracted by "the rollers," as being an unsolved problem in ocean meteorology, and I made arrangements for future observations to be kept by Mr. George Bruce, of the Customs Department, rather more fully than hitherto.

(15) At the Island of Ascension I was so fortunate as to be allowed to occupy the signal station at the summit of Cross Hill, a steep conical hill of volcanic cinder rising to 870 feet above the sea-level, and immediately overlooking Garrison and the landing-place on the leeward side of the island, as well as the lowlands of the interior of the island to windward, with Green Mountain bearing east-south-east about three miles distant. Here I observed, not only the motions and phenomena of clouds above me, but also observed their shadows on the ground and sea beneath me, so that I was able to determine the heights and linear velocities by the simplest mathematical methods. Certainly there are few, if any, spots in the world where the phenomena of the trade-winds with their annual and their irregular changes can be more successfully observed. I have certainly never before occupied a position so favourable for all manner of studies of the

clouds, winds, twilight phenomena, and the "rollers"; nor could any place be found where these particular phenomena are more highly developed.

(16) With regard to the "rollers," I would say that previous studies at Saint Helena had led me to think that undoubtedly the heavy surf constituting their prominent characteristic as described by all previous observers must be due to distant winds, not necessarily storms; and that, as an earthquake wave can traverse the whole of an ocean in a day, so the heavy swell attending a hurricane or a "norther," could easily pass to Ascension and Saint Helena from the most distant parts of the North Atlantic Ocean.

Within a week the "single-roller flag," and finally the "double-roller flag" was displayed at the Garrison landing, and I found myself looking down upon the phenomenon that had so long been a mystery. The first glance showed that the character of the phenomenon had been wholly mistaken; and on subsequent inquiry I found that probably no observer of intelligence had ever undertaken the slight hardship of a solitary residence on Cross Hill for the purpose of studying the rollers.

Otherwise it would be inconceivable that some one should not ere this have recognized a feature that certainly could never be seen from the deck of a vessel or from a lower station—namely, that the rollers are essentially the deflection around to the leeward side of what would be merely a heavy swell on the windward side of the island; and that the double rollers are simply the interference of the two sets of rollers coming around the island by the right hand and by the left. A swell such as would be caused in the open sea by a trade-wind of force 4, blowing for two days over a limited part of the ocean, will, on reaching the windward side of Ascension, or Saint Helena, produce a phenomenon on the leeward side precisely such as anyone can reproduce by studying the interference of waves in shoaling spots in a small tub of water. The angle at which the rollers interfere to produce double rollers at Garrison landing is about 135°; and as you proceed further from the island to leeward, the angle diminishes. When we sailed away from the island I was able to determine the angle as being about 40° at about fifteen miles distance. It will be at once a matter of surprise that rollers are peculiar in their severity at Ascension and Saint Helena; for other islands might be expected to show similar phenomena. But the fact is that the severity of the rollers depends first on the shape of the island; second, on its size; third, on the location and character of the shoals which surround it, all taken in connection with the length and height of the original swell; so that we should not expect many islands to possess the necessary combination of peculiarities. In fact, I have thus far learned of only one other island—namely, Saint Paul de Noronha, where the roller phenomena are conspicuous. At the Island of Barbados I particularly observed an appreciable swell curl around to the leeward side of the island from both its northern and southern extremity, and was told that occasionally these (which might be so-called single rollers) would be troublesome; but the island is so shaped that before these rollers interfere and conspire together, they have dwindled into an unimportant swell.

(17) Our second approach to and passage through the doldrums, in April 1890, served to give me the clue to a satisfactory solution of the question as to how it is that the north-east trades interact at the equator—namely, whether they pile up over the doldrums and flow back as massive upper currents, according to the ancient theory; or whether they interpenetrate each other, according to Maury's theory; or whether they revolve around each other in horizontal curves, slipping past each other to the north and south; or whether they meet and conspire together in a powerful upper easterly wind, as Abercromby maintains. This question is now readily settled by recognizing that the important general features of the circulation in the lower atmosphere are as follow:—As the trades approach the doldrums from either side, there is a continual diurnal uprising and return flow taking place, so that the returning upper anti-trades are perpetually being supplied by new air, and derive scarcely any of their material from the central region of the doldrum itself. Each successive ascending mass diminishes the inertia of the matter in the lower trade wind by necessitating the descent of a little air from the anti-trade, so that the inertia of the lower trade considered as a whole is all used up by the opposition of these descending waves, some time before it can reach the doldrums. This causes the broad irregular calm space near the equator to have no horizontal motion, and only a diurnal vertical interchange. The motion of this doldrum region horizontally in either direction depends upon the balance of pressure on the great areas of moving air around it; and it can, I believe, be deduced from anemometer records from a few such island stations as Ascension and Saint Paul de Noronha. A vertical section of the trades would show them to be wedge-shaped, being shallower at the high latitudes, while the overlying anti-trades are deeper at high latitudes. In the doldrums, as high up as clouds are formed, the prevailing characteristic of the circulation is a vertical one repeated diurnally for months and years without any systematic interchange of air to the north or south.

(20) At Barbados I was able to secure a large amount of manuscript meteorological data, and was delighted to find that the magnificent system of rainfall stations developed by Sir Rawson W. Rawson, Governor at Barbados 1866-75, is still maintained by the Government; and although the number of stations had fallen from 250 to 80, yet the system remains one of the best in the world.

CLEVELAND ABBE.

The unfortunate appearance of "the grip" on board the *Pensacola*, when two days out from Barbados, caused our prompt quarantine on reaching Bermuda. Meteorological work at the latter place was, therefore, necessarily much abridged. Mr. Preston was, however, permitted to land with his instruments at Quarantine, Nonsuch Island; and by remaining after the departure of the *Pensacola*, he was enabled, through the courtesy of His Excellency Governor Lieut.-General Newdigate-Newdegate, to carry on the magnetic and gravity work as elsewhere, thus preserving the chain of Expedition stations unbroken.

DAVID P. TODD.

Amherst College Observatory, Massachusetts,
March 24.

VEGETATION OF LORD HOWE ISLAND.

THERE is nothing absolutely new to announce concerning the flora of this remote islet; but what has been published is in the form of Government reports, which have a comparatively restricted circulation, and many persons who would be interested in their contents are unaware of their existence. And even when one knows of the existence of such reports, it is often difficult to procure them. Through the intermediary of Sir Saul Samuel, Agent-General for New South Wales, the library of the Royal Gardens, Kew, has just received a copy of a report on the state and prospects of Lord Howe Island, with a number of photographic illustrations of the scenery and vegetation of the island; and it is on account of some of these illustrations that I have thought it worth while making known to the readers of NATURE the existence of such a report, though it was published as long ago as 1882. Unlike the majority of such documents, this report is too meagre; "Thompson's farm" and other matters being mentioned and illustrated in such a manner as to take for granted an amount of previous knowledge that very few readers could possibly have possessed.

Although so remote and so small, Lord Howe Island supports an indigenous flora of a highly interesting character, especially interesting because it includes some plants whose nearest allies are natives of New Zealand. The island is about 300 miles from Port Macquarie, the nearest point of the Australian mainland, in 31° 30′ S. latitude. It is seven miles long, with an average breadth of about a mile, and the basalt mountains rise to a height of nearly 3000 feet. The soil is fertile, and is, or rather was, everywhere covered with vegetation. The scenery is beautiful; the climate is described as unsurpassable, and a great future is predicted for the island as a sanatorium, "when the Australian colonies become more densely inhabited." Without waiting for the time when Australia will be crowded with inhabitants, Lord Howe Island might be made a pleasant holiday resort, involving just enough of a sea voyage to be exciting and exhilarating, and not long enough to be monotonous.

The most complete account of the flora yet published is by Mr. Charles Moore, Director of the Botanic Gardens, Sydney, N.S.W., though many of the new plants then—1869—collected by him have since been published in various books and periodicals. The dominating feature in the vegetation is composed of palms, of which there are three or four species peculiar to this island—a condition of things paralleled in remote insular floras only in the Seychelles. Next in interest and prominence are the four or five endemic species of tree ferns, which, however, we are informed, in the illustrated report referred to, by the Hon. J. Bowie Wilson (botany by Mr. J. Duff), are fast disappearing from the lowlands, and will soon be extinct if their removal is not absolutely prohibited. In this connection one is gratified to find both the chief of the Commission of Exploration, and the botanist attached thereto, strongly urging the Government to take active steps to preserve the beautiful vegetation of the island, and especially to make no concessions, nor grant any leases that might entail any further destruction of the woods. Commonest among the other trees are *Hibiscus Patersonii*, *Myoporum acuminatum*, and *Ochrosia elliptica*—all three Australian trees; one or more species of *Ficus*, and one or more endemic species of screw-pine. One of the vegetable wonders of the island is a huge banyan-tree (*Ficus* sp.), said to cover three acres of ground; but no particulars are given of this remarkable tree, beyond a photograph of a portion of it. This is rather disappointing, because of all the famous banyan-trees in India, some of which are encouraged by artificial means in the development of the aërial descending roots, which eventually become auxiliary trunks, few surpass in size this one, on such a speck of an island. The celebrated banyan between Poona and Kolapore, in the Bombay Presidency, is, indeed, the only one, of which I have found a record, that covers a greater area than the Lord Howe Island banyan, and that, according to measurements given of the spread of its branches, must cover between six and seven acres.

In striking contrast to the flora of Australia, the flora of Lord Howe Island, like that of New Zealand, contains exceedingly few species of the large natural order Leguminosæ. Out of five species collected, three are common sea-side plants that often establish themselves on a shore from seeds cast up by the waves. Of the other two, one belongs to the otherwise exclusively New Zealand genus *Carmichaelia*, and the other, *Sophora chrysophylla*, is also a native of the mountains of the Sandwich Islands, and has hitherto been found nowhere between these two distant parts of the immense Pacific Ocean, and nowhere else in the world. From the foregoing notes may be gathered what an interesting flora that of Lord Howe Island is, and it is to be hoped that the recommendations of the Commissioners for its preservation have been carried out by the Government of New South Wales.

W. BOTTING HEMSLEY.

NOTES.

AT the meeting of the Royal Geographical Society on Monday, it was announced that the following awards had been made:—To Sir James Hector, M.D., F.R.S. (Director of the Geological Survey, &c., of New Zealand), Royal Medal; to Dr. Fridtjof Nansen, Royal Medal; to Mr. William Ogilvie, the Murchison grant; to Mr. W. J. Steains, the Back grant (one year); to Dr. David Kerr Cross, the Back grant (one year); to Lieutenant B. L. Sclater, R.E., the Cuthbert Peek grant; to Mr. A. E. Pratt, the Gill memorial.

THE next ordinary general meeting of the Institution of Mechanical Engineers will be held on Thursday evening, April 30, and Friday evening, May 1, at 25 Great George Street, Westminster. The chair will be taken at half-past seven p.m. on each evening by Mr. Joseph Tomlinson, the President. The following papers will be read and discussed, as far as time permits:—Research Committee on marine-engine trials: report upon trial of the steamer *Iona*, by Prof. Alexander B. W. Kennedy, Chairman; on some details in the construction of modern Lancashire boilers, by Mr. Samuel Boswell, of Manchester. The anniversary dinner will take place on Wednesday evening, April 29.

AT the Physical Society, on Friday, in addition to the papers already announced, an account will be given, by Prof. Silvanus P. Thompson, of erecting prisms for the optical lantern. A new prism by Mr. Ahrens will be exhibited.

THE Kew Committee of the Royal Society have given notice that they are prepared to examine, at the Kew Observatory, photographic lenses, for the purpose of testing them and of certifying their performance.

THE twenty-second annual meeting of the Norfolk and Norwich Naturalists' Society was held in the Norwich Museum on March 31 last, Mr. Henry Seebohm, the President, in the chair. Dr. F. D. Wheeler was elected President for the ensuing year. The Treasurer's report showed that the Society was in a sound position financially, and that the present number of members is 254. Mr. Seebohm read his presidential address, and referred to the loss the Society had sustained by the death of Mr. J. H. Gurney and Mr. John Gunn.

WRITING on April 4, a Constantinople correspondent of the Vienna *Vaterland* says that, on the preceding day, the hamlet of Adil-Djevas, in the district of Van, in Armenia, had been destroyed by an earthquake. One hundred and forty-six houses had been destroyed, 240 other buildings had been much injured, and hundreds of lives had been lost.

ACCORDING to a telegram sent through Reuter's Agency, a large body of water has been discovered at El Golea, in the Sahara Desert, about 120 feet below the surface. It throws up nearly forty gallons per minute at present, and it is anticipated that the yield will be much greater when more perfect access to the water is attained. The discovery is regarded as of high importance, as this is the first time that water has been found in the Sahara at such a slight depth underground.

A LADY sends the following note on a meteor seen by her to pass across the sky from north-west to south-east about 7.20 p.m., March 26. It was seen from the bridge over the River Fal, at Ruanlanihorn, Cornwall:—"Body very bright, brilliant white light, towards the back a slight flame-like appearance, a slight delicate tail rather more inclined to reddish light.

It travelled fast across the sky, and I saw it first when just about the highest centre, and it disappeared to the south-east behind the hill (our copse and glebe), which was just in front of me as I was crossing the sette on my way home. It travelled fast, but not nearly so fast as any meteor I have ever seen before; but with a quick rate, of steady perceptible time."

AMONG the results already obtained from the oceanographic expedition of the *Pola*, organized by the Academy of Sciences of Vienna, are the following:—The water of the central basin of the Mediterranean was found to be warmer, denser, and richer in dissolved salts, than the western basin. As regards the penetration of light into the sea, a white disk was visible only at a depth of 43 m., but photographic plates were affected at a depth of 500 m. Starting from the surface of the sea, the quantity of oxygen dissolved at first increases with the decrease of temperature; but then again decreases, so that at a depth of 3000 m. the proportion is the same as that at the surface. In no case was any free carbonic acid found. The nitrogenous substances in solution vary in inverse proportion to the depth; that of ammonia varies but slightly, but is greater in the lower strata.

IN the course of excavations which are being carried out in the neighbourhood of Vienna by the Academy of Sciences, a cavern was lately discovered on the slope of the mountain at Baden. A correspondent writes to the *Times*:—"It was plain on a cursory inspection that the cavern had been used not only in the Middle Ages, but long previously. At the time of the Roman occupation Baden was the encampment of a veteran legion who were well acquainted wit the good qualities of the waters. Decided remains of the foundations of a vestibule were found at the entrance of the cave. In a niche hewn out of the rock was an altar with the sacrificial stone table. In front of the cavern was a regularly-constructed building, fully 10 feet below the surface of the ground above, designed probably to conceal the cavern behind, which was most probably employed as a temple to Mithras. There were two stalls for horses, fragments of utensils, knives, flint arrow-heads, carved bones, mixed up with Roman coins, lamps, and stamped tiles."

AT the meeting of the French Meteorological Society on March 3, a communication from M. Marès showed that the weather in Algeria had been as remarkable during the last winter as in Europe. The author stated that in many localities the excessive rainfall had prevented the sowing of seeds, and in the mountainous districts, where the sowing had taken place early, the seed had been swept away by the torrents. About the third week in January a heavy fall of snow lay on the Mitidja and the Sahel for two whole days; the writer states that for the last thirty-five years, although he had sometimes seen snow fall, it did not lie an instant on the ground. The effects had been disastrous to early crops and to many animals.

THE April number of *Himmel und Erde* contains an article by Dr. W. J. van Bebber, of the Deutsche Seewarte, on the typical weather conditions of winter. The writer shows very clearly by means of charts how the disposition of barometric pressure over the Atlantic and the continent of Asia regulates the weather over Western Europe. Nearly twenty years ago the synoptic charts issued by Captain Hoffmeyer, of the Danish Meteorological Institute, showed that there were three large areas of very low barometric pressure in the Atlantic, the most important being south-west of Iceland, and two smaller areas, one on the eastern side towards the northern Arctic Ocean, and another on the west side towards Davis Straits. These areas cause the westerly and south-westerly winds which bring the damp and warm air over Europe. The shifting of their positions causes the variations in our wind-system. M. L. Teisserenc de Bort has pointed out the important part also played by areas of high barometer, which has given greater importance to the Danish synoptic charts. The most important area of high pressure for Western Europe is that stretching eastwards over the Azores and Madeira. If this area shifts north-eastwards towards France, it blocks the way of the air over the ocean, and the weather becomes foggy and cold. Another important barometric maximum persists over Central Asia. This maximum is subject to frequent modifications; sometimes it splits up into two parts, one of which not rarely shifts as far westwards as Scandinavia, and produces a persistence of cold easterly winds over Western Europe—especially when the pressure over Southern Europe is low, which was generally the case in the past winter.

THE new number of the *Mineralogical Magazine* opens with a paper on cassiterite, "sparable tin," from Cornwall, by R. H. Solly. The other papers are: twins of marcasite in regular disposition upon cubes of pyrites, by C. O. Trechmann; the tetartohedrism of ullmannite, by H. A. Miers; a student's goniometer, by H. A. Miers; on an eclogite from Loch Duich, by J. J. H. Teall, F.R.S.; on a micro-granite containing riebeckite from Ailsa Craig, by J. J. H. Teall, F.R.S.; on occurrences of riebeckite in Britain, by Grenville A. J. Cole; on a rapid method for the accurate recognition of sulphides, arsenides, antimonides, and double compounds of these bodies with metals, by Charles A. Burghardt; a system for constructing crystal forms by the plaiting of their zones, by J. Gorham. There are also reviews and abstracts.

OUR young contemporary *Neptunia*, published at Venice, includes in its programme an account of the existing biological stations in various parts of the world. In its first number (January 1891) there is an historical sketch of the work done in the Marine Laboratory of Luc-sur-Mer, Normandy, attached to the Faculty of Sciences at Caen. Established in 1883 at the suggestion of Prof. Deslongchamps, of Caen, and supported by a grant of 30,000 fr. from the Council-General of the Calvados, it has since been under the direction, successively, of Profs. Delage and Laffine. During the seven years of its existence some admirable biological work has been done in this laboratory, the results of which have been published in the French scientific journals. The researches carried on in 1888–89 include a "Memoir on the Organization of the Chætoptera," by Prof. Laffine; "Researches on the Lower Algæ," by M. E. Dangeard; "Researches on the Sponges of the Manche," by M. Topset; "On the ink-bag of the Mollusca," by M. Letellier. In a later number of the same journal there are accounts of the movable zoological station of the Committee for the Exploration of Bohemia, and of the marine zoological laboratory at Rapallo.

IN a recent report by Lord Vaux of Harrowden, Secretary to the British Legation at Stuttgart, on agriculture in Würtemberg, reference is made to agricultural education in that State. This is cared for by numerous schools and societies, and appears to be fully appreciated by the peasants and others. Almost every institution of this sort had greater demands made upon it in 1889 (the year to which the report specially refers) than in the previous year. The Agricultural and Gardening School had its normal number of students; the School of Vineyards, in consequence of increasing demands for tuition in this branch, was again forced to exceed its statutory number of pupils; the Agricultural Winter School was attended by 103 scholars, being an increase of six on the previous year. A sixth school was added to the five already in existence for teaching country girls and young women farmhouse and dairy work. The travelling teachers of husbandry, as well as those specially devoted to orchards and vineyards were in great request among local societies and by the communal authorities. Sixty-four students attended the lectures upon orchard cultivation; ninety-two farriers were taught at the various veterinary colleges and schools throughout the country. The winter evening agricultural schools, reading clubs, and local libraries all showed a considerable increase both in numbers and in attendance. Altogether some 23,400 persons attended agricultural schools or lectures on husbandry during the year. This is rather more than 1 per cent. of the total population of the country, and is good evidence that the people as a rule do not neglect the opportunities given them of becoming successful agriculturists.

Boron iodide, BI_3, has been prepared by M. Moissan, and its properties, which are of a somewhat remarkable nature, investigated. It may be obtained in three ways: (1) by leading gaseous hydriodic acid mixed with the vapour of boron chloride, BCl_3, through a porcelain tube heated to redness; (2) by the action of iodine upon boron at a temperature of 700°–800° C.; (3) by the action of hydriodic acid gas upon amorphous boron. The third method affords the best means of preparing the new substance in quantity. A current of gaseous hydriodic acid is first well dried by passage through porous calcium iodide; it is then led over amorphous boron contained in a hard glass tube heated to a temperature approaching that of the softening of the glass. At the commencement of the experiment a small quantity of iodine vapour makes its appearance, and is allowed to escape. When this ceases a dry receiver is attached to the end of the combustion tube, and a more or less deeply coloured crystalline product begins to collect. In a short time the reaction becomes very energetic, large quantities of the crystalline body being deposited, of a bright reddish-purple colour, and almost pure hydrogen escaping. The coloration is due to a small quantity of admixed iodine, for if the solid product is treated with carbon bisulphide it entirely dissolves, forming a solution of the same colour as that of iodine in carbon bisulphide, and which is rendered colourless by agitation with mercury. The solution in carbon bisulphide deposits on evaporation colourless transparent tabular crystals, somewhat nacreous in appearance, of pure boron iodide. The crystals are very sensitive to light; their colourless solution in carbon bisulphide becomes deep red in half an hour, owing to the liberation of iodine under the influence of diffused daylight. The crystals melt at 43° to a liquid which boils undecomposed at 210°, without any appearance of free iodine vapours. The crystals are exceedingly hygroscopic, attracting moisture with great rapidity, and thereby suffering decomposition. In contact with water itself the decomposition is instantaneous, boric and hydriodic acids being formed, $BI_3 + 3H_2O = H_3BO_3 + 3HI$. When heated in air or oxygen, boron iodide burns readily with a brilliant flame deeply coloured with iodine vapour, clouds of boric anhydride, B_2O_3, being also produced. Melted sulphur attacks it likewise with considerable energy, iodine volatilizing, and a substance being formed which on the addition of water yields a precipitate of sulphur and evolves sulphuretted hydrogen, presumably a sulphide of boron. Phosphorus reacts in the cold with incandescence. With oxychloride of phosphorus, $POCl_3$, a crystalline compound appears to be formed with considerable rise of temperature. Silver fluoride at once invokes incandescence, a violent evolution of gaseous fluoride of boron, BF_3, occurring together with formation of silver iodide. Ethyl alcohol likewise reacts with rise of temperature, a product being obtained which on distillation yields ethyl iodide, the residue consisting of boric acid, $3C_2H_6O + BI_3 = H_3BO_3 + 3C_2H_5I$. Ethyl ether forms with boron iodide a brown liquid, also with considerable evolution of heat, which appears to consist of ethyl iodide and boric ether: $3(C_2H_5)_2O + BI_3 = 3C_2H_5I + B(OC_2H_5)_3$; for on the addition of water to the product, ethyl iodide, boric acid, and alcohol are obtained.

The additions to the Zoological Society's Gardens during the past week include a Spiny-tailed Mastigure (*Uromastix acinthinurus*) from Algeria, presented by Mrs. W. Williams; two Chipping Squirrels (*Tamias striatus*) from North America, presented by Mr. A. W. Jutson; a Brown Milvago (*Milvago chimango*) from South America, presented by Mr. J. Mand; three Puff Adders (*Vipera arietans*) from the Cape of Good Hope, three Egyptian Cobras (*Naia haje*) from Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; a Tuatera Lizard (*Sphenodon punctatus*) from New Zealand, presented by Mr. Thos. E. Phillips; a Red-spotted Lizard (*Eremias rubro-punctatus*) from the Pyramids of Dashoor, presented by Dr. Drewitt; two Scorpions from Alexandria, presented by Mr. Sidney R. Carver; three Partridge Bronze-winged Pigeons (*Geophaps scripta*), a Brush Bronze-winged Pigeon (*Phaps elegans*), three Maned Geese (*Bernicla jubata*) from Australia, purchased.

OUR ASTRONOMICAL COLUMN.

The Solar Corona.—The fourteenth number of the Publications of the Astronomical Society of the Pacific contains several notes on the solar corona. Prof. Charroppin gives the results of an investigation into photographs of the corona, and recommends the following methods in order to obtain greater extension of coronal streamers: (1) to use orthochromatic plates; (2) the greatest precaution to guard from all foreign light; (3) short exposures to obtain the polar filaments and the inner corona; (4) long exposures to secure the extension of the outer corona; (5) photographing each wing separately, and keeping the brighter part of the eclipse out of the field. Prof. Frank H. Bigelow gives a brief summary of the result of a discussion of a photograph of the corona streamers of the eclipse of July 29, 1878, according to the law of equipotential surfaces. He shows that the repulsion of the surfaces of infinitesimally small particles, obeying this law, is all that is required as a fundamental conception, in order to arrive at a physical interpretation of the facts. Lastly, Mr. Schaeberle gives a short account of the principles and results of the mechanical theory of the corona, to which reference has been made in a previous number (Nature, vol. xlii. p. 68). The full account of the investigation will appear in a report to be issued by the State Legislature. Beginning with the theorems, that (1) the eruptions on the sun's surface are most active and numerous in the sun-spot zones; (2) the sun rotates about an axis passing through its centre; (3) this axis is inclined to the plane of the earth's orbit at an angle of about 82¾°, Mr. Schaeberle derives formulæ which give results showing "that the observed shapes of the equatorial extension or wings of the corona can be satisfactorily accounted for by supposing them to be the envelopes of systems of streamers ejected from the sun-spot zones with initial velocities of less than 380 miles per second (such velocities as have been observed in the higher regions of the prominences, for example)." He then shows on mechanical principles that the curious forms of the "polar rays," which are seen in any corona can be produced by the perspective overlapping of systems of nearly right line streamers originating within the sun-spot zones, and have therefore no objective existence. The *résumé* given by Mr. Schaeberle is a proof that he has thoroughly worked out his theory, and tested its capability of explaining the numerous coronal forms. We therefore look forward with interest to the publication of the Eclipse Report, containing the extended argument in favour of a theory which certainly rivals all others in simplicity.

The Photographic Chart.—A recently published *Bulletin du Comité international permanent pour l'exécution photographique de la Carte du Ciel* is distinguished by several interesting and important articles. M. Kapteyn and M. Gautier contribute notes on the construction and use of the apparatus for the measurement of the photographs, and Dr. Scheiner describes a simple method used at Potsdam for the exact orientation of the telescope. In a paper on the law of photographic diameters of stellar disks, Max Wolf compares the disks of Polaris and neighbouring stars, and the group G.C. 4410, obtained by exposures varying, in geometrical progression, from 1 to 1024 seconds, and deduces the conclusion that the increase in diameter gets smaller and smaller as the exposure increment is augmented. M. Dunér discusses the vexed question of the determination of the photographic magnitudes of stars by means of measures made on the negatives, and propounds the following definition :—"The relation between the light of two stars which differ from each other by a photographic magnitude is expressed by the factor with which the time of exposure of a given plate must be multiplied or divided in order to render the diameter of the image of a star on the new *cliché* equal to the image of another star on the given *cliché*." A paper by M. Prosper Henry, on the value of atmospheric refraction for different portions of the spectrum, has previously been noticed (NATURE, vol. xliii. p. 400).

COMET BARNARD-DENNING (a 1891).—Prof. Berberich gives the following elements in *Astronomische Nachrichten*, No. 3027, for the comet discovered by Mr. Barnard, of Lick Observatory, on March 29·695, G.M.T. and by Mr. Denning at Bristol on March 30·417 G.M.T.

Mean epoch = 1891 April 27·730 Berlin mean time.

$$\left.\begin{array}{r} \text{Longitude of perihelion} = 178^\circ\ 14'\!\cdot\!30 \\ \text{Longitude of ascending node} = 194\ 13\cdot14 \\ \text{Inclination} = 120\ 30\cdot52 \end{array}\right\}\text{ Mean Eq.}$$

Perihelion distance = 0·40652 earth's mean distance.

On the 18th inst. the comet is in R.A. 1h. 42m. 9s., Decl. + 23° 41'·6, and is therefore not well situated for observation, although it is increasing in brightness.

THE PLANET MERCURY.—At the present time the planet Mercury is in a position most favourable for observation, and will continue so until about the 25th of this month. Appearing as an evening star, it will be found near the western horizon just after sunset, and those who have no optical means at their disposal should look out for it at about 8 o'clock on the 19th or 20th of this month, when it will resemble a star of about the first magnitude, and will be a little to the westward of the Pleiades. Although the planet Mars is also situated near this region, the detection of Mercury can easily be made, by reason of its colour, which is of a far whiter hue than that of the first-mentioned planet. During the latter end of the present month and the first week of May the planet will be almost invisible, being lost in the rays of the sun, and its next appearance will take place as it transits the disk of the sun on the 9th of the same month. At Greenwich the transit will only be partial, as the sun will rise at 16h. 19m. (Greenwich mean time), so that only the internal and external contacts at egress can be observed.

For the benefit of those wishing to observe the planet during the present week, the following extract from the *Nautical Almanac* may be useful :—

	Apparent R.A. Noon. h. m. s.		Apparent Declination. Noon. ° ' "
April 16 ...	2 50 13·46	..	N. 19 2 59·0
,, 17 ...	2 54 42·75	...	19 27 55·9
,, 18 ...	2 58 52·66	...	19 50 6·0
,, 19 ...	3 2 42·52	...	20 9 29·4
,, 20 ...	3 6 11·74	...	20 26 5·4
,, 21 ...	3 9 19·79	...	20 39 54·3
,, 22 ...	3 12 6·27	...	20 50 56·5

NEW ASTEROID (308).—M. Borelly discovered the 308th asteroid on March 31

THE WHEAT HARVEST IN RELATION TO WEATHER.

THE general law of wheat production in England was stated in the *Times* of August 30, 1881, as follows : "The yield of wheat is proportional to the summer temperature, with the modifying conditions of rainfall, prevalence of cloud, character of the weather at blossoming time and during the harvest, and the state of growth at the commencement of the summer" ; and it was added, "The growing influence of a high or low thermometer is established by the observations of many years." To test the law, superior and inferior harvests may be correlated with their summer temperatures and rainfall. For this purpose the meteorological records of the Royal Observatory, Greenwich, will be used. The mean temperature of June, July, and August, and the total rainfall for these months, will be taken for the summer.

I.—*Superior Wheat Harvests.*

Year.	Character.	Temperature.	Rainfall.
		°	inches.
1775	Plentiful	62·0	?
1779	Plentiful	62·3	?
1791	Abundant	59·5	Dry
1818	Most abundant	64·3	1·4
1819	Fine	60·3	4·6
1820	Productive	58·0	8·2
1825	Early and good	62·0	3·3
1826	Remarkably early and very great	64·0	5·1
1827	Good	60·0	2·9
1833 (a)	Abundant	59·4	6·7
1834 (b)	Early, very productive	62·5	11·3
1835	Good	62·6	4·5
1840	Fine yield	59·8	3·9
1849	Above the average	61·0	3·8
1851	Above the average	61·0	7·2
1854	Extremely good	59·0	5·6
1857	Above the average	63·9	6·0
1858	Above the average	62·5	5·7
1863	Abundant	60·3	6·6
1864	Good	59·6	2·5
1868	Productive	64·4	4·1
1874	Very good	60·9	6·4
1888 (c)	Above the average	58·4	13·8
	Mean	61·2	5·68

II.—*Inferior Wheat Harvests.*

Year.	Character.	Temperature.	Rainfall.
		°	inches.
1789	Very deficient	59·7	Wet
1792	Inferior	58·3	Wet
1795	Very defective	57·8	?
1800	Bad	60·7	Wet
1810	Scanty	60·0	?
1811	Very scanty	59·0	?
1812	Very defective	56·0	?
1816	Very great deficiency	55·2	8·4
1817	Deficient	57·4	7·9
1821	Inferior	57·8	7·0
1823	Deficient	57·8	7·1
1828	Bad	60·3	12·0
1829	Inferior	59·0	9·4
1838	Late, unproductive	59·1	7·3
1839	Damaged	59·3	7·6
1848	Very bad	59·5	10·6
1852	Below the average	61·7	11·4
1853	Bad	60·1	11·0
1860	Very deficient	56·7	11·6
1867	Deficient	59·8	10·2
1873 (d)	Very deficient	61·7	7·6
1875	Very unsatisfactory	60·3	9·8
1876 (e)	Unsatisfactory	62·7	3·7
1877 (f)	Unsatisfactory	62·0	6·0
1879	Worst known	58·5	13·3
1880	Deficient	60·6	7·1
1881	Deficient	61·1	7·9
1886 (g)	Deficient	61·0	4·1
	Mean	59·4	8·6

(a) May was very dry.
(b) The winter was very mild ; the spring very dry.
(c) The winter and early spring were very cold ; May was very dry, with much sunshine.
(d) Frost occurred at blooming-time.
(e) and (f) The spring was cold.
(g) The winter and early spring were very cold ; May was very wet.

It is not easy to understand how to correlate the harvests with any specified meteorological datum, for the harvest itself may vary greatly in different counties. But if it is possible to differentiate the meteorological conditions with reference to the harvest, it is quite impracticable to integrate them, or to consider them all together. We shall not, however, be far wrong if we infer from the preceding simple tabulations that: good harvests of wheat accompany hot and dry summers; bad ones, cold and wet. The yield of wheat in England probably depends much more upon the summer dryness than the high temperature. A mean temperature above the average, and small rainfall during the months of June, July, and August imply much clear sky and bright sunshine. A mean temperature below the average for these months implies prevalence of cloud intercepting sunshine, but does not always or necessarily imply large rainfall. Excessive rainfall generally, unless it is due to local thunderstorms, implies overcast weather. Of course, mischief to the growing crop may be of too early date to admit of good yield from even the most favourable summer weather.

The largest wheat harvests have been in those years in which the sun exerted most power, and when, from midsummer until the full ripening, intermittent glowing heat, with fewest interruptions of cloudy weather, or humidity, was experienced. Of the heavy-yielding wheat years, 1854 was a dry summer, 1857 and 1858 had summers of exceptionally long-continued heat. The large wheat crop of 1863 was connected with a fine dry summer; that of 1864 was related to a prolonged drought from July 4 to August 21. The hot summer of 1868 brought a bulky wheat yield. As regards the abundant harvest of 1874, July was much above its average temperature. Good wheat crops resulted from very fine hot summers in 1846, 1847, 1870; and good wheat crops attended the droughty summers of 1885 and 1887. Bad harvests seem rather to depend upon large summer rainfalls than upon low mean temperatures, as in 1828, 1852, and 1853. The years 1886 and 1888 contradict the law, and would seem to point to the effect of the weather in May, which was of opposite character in these two years. Again, the temperature and rainfall indicate good, not bad, harvests for 1876 and 1877. The good harvest year 1851, and the bad one 1873, were on a par meteorologically; and 1849 and 1876 might exchange places, so far as the weather seems concerned. The hottest and driest summer, 1818, had apparently the best harvest; the wettest, 1879, the worst; the coldest, 1812, a very defective one; and 1860, with its cold and wet summer, had a very deficient harvest.

In estimating the influence of the weather upon the resulting crops, the character of the winter and spring ought to be taken into consideration, for, according to Sir J. B. Lawes, "The great influence upon the subsequent growth of wheat of the weather before the period of active above-ground growth, was clearly illustrated in 'Our Climate and our Wheat Crops,' in the case of the season of 1854. The summer of that year was comparatively cold and sunless, yet the wheat crop was one of the best of the present century. The early winter had been unusually cold, but the remainder and the early spring were warmer than the average, and the season was extremely dry from seed-time to harvest, the mild spring and the dryness obviously compensating for the deficiency of temperature during the summer months." The year 1890, like 1854, had high temperature winter and spring; and, according to Sir J. B. Lawes, "The produce of both seasons clearly illustrates the fact that prevailing high temperature during the period of active growth and even of ripening, are not essential for the production of large crops of wheat."

The features of the winter 1890-91 make it the most extraordinary winter of the century in England; its effects, therefore, upon agriculture will be watched with more than passing interest. A writer in *Ciel et Terre* propounds the law that cold winters are followed by cold summers, and thereupon predicts that the summer of 1891 will be cold. Now, low summer temperature is usually attended with rainy weather, so the summer may be wet. The Greenwich observations apparently bear out these deductions, but not without exceptions. For instance, the summer of 1847 was warm and dry, after a very cold winter. However, the probabilities seem in favour of a cold and wet summer. Nevertheless, it should be pointed out that, assuming a cold summer and given a cold preceding winter, it follows that the spring and autumn must be either mild or seasonable, otherwise the year altogether will be remarkably deficient in temperature. Protracted winters were followed by cold wet summers and bad harvests in 1811-12, 1813-14, 1815-16, 1859-60, 1878-79; very cold winters by cold and wet summers in 1816, 1820, 1823, 1830, 1836, 1838, 1841, 1845, 1847. There are not wanting weather-wise people who predict that 1891 will be a dry year, on the theory of the sapient meteorologist, taken *per contra*, that rainy weather prolongs itself, that the more rainy weather you have the more you may expect. They argue, 1889 and 1890 were exceptionally dry years, so 1891 may be even drier. Last spring, up to the end of May was curiously rainless, and, from August onward, every month has shown less than the average quantity of rain. December and January had already parched the ground; February made it moistureless. Some rain came on March 7, but the fall for the month was far below the average in all parts of the British Isles except North Scotland. Want of moisture would gravely affect the prospects of the harvest.

In conclusion, one or two inferences remain to be drawn from the foregoing tabulation. Between the mean summer temperature of the superior harvest years and that of the inferior there is only a difference of 1°·8 in favour of the former; but this means so much more heat daily over 92 days. The mean rainfall for the summers of inferior harvest years exceeds that of the superior by 2·9 inches, which means that the wet summers had half as much more rain than the dry ones. Hence, it would seem that rainy summers rule the harvests much more potently than the mean temperatures. This influence seems conformable to the well-known character of rainy summers, in England, as regards sunshine, for they are wofully deficient in that vital element in the growth and maturity of the crops. The wheat yield in England follows the summer rainfall inversely. Good wheat years are those of hot dry summers. Bad wheat years are those of very wet sunless summers.

A JOURNEY IN SOUTH-WEST CHINA.

At the last meeting of the Royal Geographical Society the paper read was on "Two Journeys to Ta-tsien-lu on the Eastern borders of Tibet," by Mr. A. E. Pratt, whose main object was the collection of natural history specimens. Ta-tsien-lu is a mountain village about 8400 feet above the level of the sea, in the province of Sz-chuen in West China—five days' journey from the borders of Tibet, and ten days' journey south-west from the Roman Catholic missionary station of Mou-pin, where Père David lived for some years, and whence he sent to Europe the valuable collections of mammals and birds which have made his name famous throughout the world. In the year 1889 Mr. Pratt spent three months in this district with Mr. Kricheldorff, making collections in natural history, and again in 1890 about the same time. The first stage of the journey to this remote district was from Shanghai to I-chang. The river Yang-tze is navigated for this distance of 1200 miles by steamers built especially in Britain for the river service, and commanded by English or American captains. Passengers change steamers at Hankow, and the whole journey occupies from ten days to three weeks, according to the state of the river and the time lost in waiting at Hankow for the next boat.

The journey from I-chang to Chung-king is generally made in Chinese house-boats, but Mr. Pratt had a boat specially built. At Chung-king the river (1600 miles from Shanghai), at high water, is considerably over a mile in width. This is a great opium-growing district. At Sui-fu, the great centre of trade for Yunnan, Mr. Pratt left the Yang-tze and entered the Min, one of its largest tributaries. The great industry of this thickly populated district on the banks of the Min is the manufacture of salt. On May 14 the party anchored for the night at a place some fifteen miles below Kia-ting-fu, reaching the city in the course of the afternoon. They left Kia-ting-fu on May 19. Their way lay through a really lovely country, beautifully watered by innumerable streams, reminding Mr. Pratt very much of Hampshire. Here, for the first time, he saw that beautiful orchid, *Dendrobium nobile*, growing wild—a mass of pink bloom. Eight hours' travelling brought them to the town of Omei-hsien, seven miles from Mount Omei, the celebrated sacred hill so well described by M. Colborne Baber. They left Omei-hsien on the 21st, and on their way met many coolies carrying the eggs of the celebrated wax insect down from the mountains. These eggs hatch out if exposed to the sun, so they are generally carried by night. The method of production of this wax has been fully described by Mr. Hosie.

After travelling through a very wild region, the party reached an elevation of 5000 feet, where Mr. Pratt gathered a lovely fragrant honeysuckle and a fine mauve-coloured primula, and saw some feathers of the famous Amherst pheasant. On May 24 they struck the main stream of the Tung river, which appears to divide the territory of the independent Lolos from that of the portion of this interesting people subject to the Chinese. Passing by the side of a range of mountains the party followed an affluent of the Tung river, and on May 26, thirty-two days after leaving Chung-king, reached Ta-tsien-chih, a long straggling village of detached clusters of houses. It stands at an elevation of 5980 feet above the sea. The mountain ends in a series of fourteen precipices, each some 200 feet high, the highest being only accessible by ladders. The climate is very much like that of England—cold, rainy, and changeable; the roses very pretty, but single, and strawberries were plentiful; and there is good shooting—wild ox, two species of antelope, two species of bear, and five of pheasant.

The party went on to Ta-chien-lu, the road leading over a pass some 10,000 feet in height. Ta-tsien-lu is a most interesting town. All sorts of Asiatics may be met in its streets, and Europeans, therefore, attract less attention here than in other places where strangers are seldom seen. The natives of the place are the wildest-looking people, invariably armed to the teeth; some of fine physique, tall and handsome, with long matted hair hanging over their faces.

The following year, 1890, Mr. Pratt made a second expedition to Ta-tsien-lu, to increase his collections. This time he carried out the intention he had formed on his previous journey, of ascending Mount Omei. This mountain is 11,100 feet high, and is regarded throughout the neighbouring countries as a spot of peculiar sanctity. There are between sixty and eighty temples on it, and about two thousand priests, and it is continually visited by many thousands of pilgrims. The mountain rises abruptly like a promontory, and can only be ascended from one side. The others are extremely steep, one of them being a precipice nearly a mile and a third high, the highest sheer declivity, perhaps, in the world. As the party approached the mountain, they passed many fine trees, of the species allied to the banyan. One particularly fine specimen, with a magnificent spread of foliage, Mr. Pratt measured, and found it to be 30 feet in circumference. The path led them at first through a wide fertile valley of rice fields, with clumps of trees scattered here and there as in a park. The mountain is covered from head to foot with undergrowth and forest, pines, hollies, and other evergreens predominating. Flowers were very abundant, wild roses, anemones, asters, yellow violets, and two species of hydrangea. Here Mr. Pratt noticed *Paxia begonia*, which he believes has no representative in Europe, but which he believes is represented in America. Near the top he found a primula and a dwarf azalea with fragrant foliage, the latter, so far as he knows, a unique specimen.

During this visit, Mr. Pratt more than once witnessed the curious phenomenon known as the glory of Buddha. Standing on the edge of the precipice, and looking down into the sea of mist which generally fills the valley below, he saw, about 150 feet beneath him, the golden disk surrounded by rainbow-coloured rings of light, which is the chief marvel of Mount Omei, and the clearest evidence of its sanctity. Every year many pilgrims commit suicide by throwing themselves down from this cliff. On May 1, accompanied by Father Soulié, Mr. Pratt made an excursion from Ta-tsien-lu to the snow-capped mountains, and pitched his tent in a forest of rhododendrons just coming into bloom, about two hours below the region of perpetual snow.

By way of summary of the vegetation, Mr. Pratt divides the country here briefly into four regions or zones:—(1) Above 16,000 feet we have perpetual snow. (2) Between 16,000 feet and 10,000 feet, rhododendrons, anemones, primulas, rhubarb, many lilies, a few asters, grass, and wild onions; of birds, *Crossoptilon thibetanum*, *Lophophorus lhuysii*, and Père David's small blue bird. (3) From 10,000 to 5000 feet—rhododendrons, coniferous trees, gooseberries, several species of currant (including one very large black currant with bunches of fruit a foot in length), undergrowth, and several species of birds. (4) Below 5000 feet there is cultivation on a few farms, and pasturage.

M. GRZIMAILO'S EXPEDITION.

ON March 25, the Russian Geographical Society held an extraordinary meeting to listen to a communication by G. E. Grum-Grzimailo about his expedition to Central Asia. The expedition consisted of M. Grum-Grzimailo, his brother, a collector, an interpreter, six Cossacks, and two men. The luggage was transported on some fifty horses and donkeys. After having crossed the Russian frontier on June 8, 1889, they soon reached Kulja, and thence went north-east, towards the spurs of the Boro-Khoro Mountains. By the way they visited Central Djungaria, in order to obtain specimens of the wild horse discovered by Przevalsky, and described as *Equus przevalski* by the late Polyakoff from one single specimen brought in by the great traveller. Four specimens more were obtained. Returning from Djungaria, the expedition proceeded, in September, to the Eastern Tian-Shan, and completed the exploration of its remotest eastern parts. The well-known oasis of Turfan proved to be a desert which has been recovered for industry only by the hardest imaginable labour. It has no water, notwithstanding the proximity of the snow-mountains of Bogdo; and its inhabitants have dug out a whole system of underground canals and wells (some of which are 300 feet deep) to irrigate the desert. The canals collect the water underground, and then bring it to the surface in the lower grounds. The whole work is so colossal that the members of the expedition compare it with the colossal works of Egypt. As to the absolute height of the oasis, M. Grum-Grzimailo pointed out that parts of it appear to be *below the level of the sea*. Of course, this conclusion of the Russian traveller, being based upon barometrical measurements only, cannot yet be taken as quite certain; but it shows that the oasis of Turfan is extremely low, and that it in no case rises more than from 200 to 300 feet. It thus must represent the bottom of a great lake, which occupied on the border of the Central Asian plateau the same position as Lake Baikal occupies now; and this quite unexpected fact is one of great importance for the physical geography and geology of the whole region.

In February 1890 the expedition reached Hami, and thence proceeded to Mor-gol. Heavy snowfalls, however, prevented their further advance eastwards; so they turned towards the south, and went to the Nian-Shan ridge, which had already been crossed in three different places by Przevalsky and Potanin. MM. Grum-Grzimailo studied that interesting ridge over a length of 300 miles, and crossed it in a picturesque gorge which brought them to the Babo-ho river, and thence to the Chinese town Yunan-tcheu. After having explored the Alps of Si-nin, they reached the Hoang-ho, and thence began their return journey. The snowstorms rendered travelling difficult, so they rested for a while at Su-tcheu, and thence, crossing the Be-tchan Mountains, went to Gu-tchen, thence to Urumtchi, and finally reached the Russian frontier on November 25, 1890. Survey has been made over a length of 4840 miles, of which 4000 miles were previously untrodden ground; latitudes and longitudes were often determined during the journey; so also were altitudes. Nearly 200 photographs were taken, and the natural history collections are sure to be very interesting.

SCIENTIFIC SERIALS.

American Journal of Mathematics, vol. xiii., Nos. 2 and 3.—In No. 2 is concluded Part I. of a lengthy article by O. Bolga on the theory of substitution-groups and its application to algebraical equations; the final section discusses groups of operations, especially those obtained from the "groups" of rotations of a regular polyhedron which leave it congruent with its first position. Part II. deals with Galois' theory of algebraic equations."—The following papers also appear:—"Quelques propriétés des nombres K_m^p," by M. M. d'Ocagne. These numbers have been discussed in a previous article (1887, p. 353), where they were defined by means of a triangle analogous to Pascal's.—"Sur les lois de forces centrales faisant décrire à leur point d'application une conique quelles que soient les conditions initiales," by P. Appell.—On certain identities in the theory of matrices, by H. Taber.—Systems of rays normal to a surface, by W. C. L. Gorton.—On the epicycloid, by F. Morley. Some interesting results of

Wolstenholme's and others are here obtained by the use of circular co-ordinates.—The reduction of

$$dx/\sqrt{A(1 + mx^2)(1 + nx^2)} \text{ to } Mdy/\sqrt{(1 - y^2)(1 - k^2y^2)}$$

by the substitution $x^2 = a + by^2/a' + b'y^2$, by H. P. Manning. A table of available forms is added, and attention drawn to those forms in it given by Cayley ("Elliptic Functions," p. 316).—A simple statement of proof of reciprocal theorem, by J. C. Field.—Related expressions for Bernouilli's and Euler's numbers, by J. C. Field.——In No. 2 appears a third memoir, on a new theory of symmetric functions, by Major P. A. MacMahon, R.A. Attention is drawn to a fundamental theorem in operations, given without proof. It is a generalization of a theorem by Sylvester which is itself a generalization of Taylor's theorem; "it enables us from any linear function P of the operators to determine another linear function Q, such that exp. $P = \overline{\text{exp.}}\ Q$," the bar in $\overline{\text{exp.}}\ u$ being used by the author to indicate that the multiplication of operators that occur in u is symbolic.—M. Joseph Perrott also contributes a paper entitled "Remarque au sujet du théorème d'Euclide sur l'infinité du nombre des nombres premiers."

SOCIETIES AND ACADEMIES.

London.

Royal Society, April 9.—"The Measurement of the Power supplied by any Electric Current to any Circuit." By Prof. W. E. Ayrton, F.R.S., and W. E. Sumpner, D.Sc.

I.—During the meeting of the Electrical Congress in Paris in 1881, one of us[1] devised a method of using an electrometer for measuring the power given to any circuit by any current. This method is the only electrical one hitherto published, the accuracy of which does not depend on assumptions either as regards the character of the current variations or as regards the nature of the circuit the power given to some part of which we desire to measure.

In view then of the present wide use of alternating currents for industrial purposes, it might have been expected that this electrometer method of measuring the power given by any intermittent or alternating current to an inductive circuit would have been extensively employed. Unfortunately, however, as pointed out by one of us in conjunction with Prof. Perry (Journal of Soc. of Tel. Engs. and Elects., vol. xvii., 1888), the use of this method is restricted by the fact that Sir W. Thomson's quadrant electrometers do not generally obey the mathematical law given for these instruments in text-books,[1] as it was supposed they did when this electrometer method of measuring power was first suggested. And hence the main result that has, up to the present time, followed from the publication of this method has been the stimulation of inventive minds to devise forms of electrometers in which the text-book law is strictly fulfilled.

In 1888, Mr. Blakesley published a very ingenious method for measuring the power supplied by alternating currents to the primary coil of a transformer, by the use of three dynamometers. The proof originally given was geometrical, and was based on several assumptions, amongst others that the currents and magnetic fluxes varied with the time according to a simple sine law. An analytical proof has recently been given (meeting of Physical Society, February 27, 1891) by one of us, in conjunction with Mr. Taylor, showing that the method gives equally good results however the currents and magnetic fluxes vary, but there still remains a serious objection to the method, as it is assumed that there is no magnetic leakage in the transformer, or, in other words, every line of force is supposed to thread each convolution of both primary and secondary coils. Further, the method cannot be used with a single circuit as the coils of one of the dynamometers must be placed in different circuits.

The employment of an electro-magnetic wattmeter for the measurement of power is well known, but errors are introduced when alternating currents are used, owing to the self-induction of the fine wire coil. Several investigators have considered the magnitude of this error, and have suggested various devices for reducing it to a minimum.

II.—Several months ago, however, while working at alternate-current interference, we noticed that it was possible to employ an extremely simple method for measuring the power supplied by *any* current to *any* circuit. This method, which has since been in regular use in the laboratories of the Central Institution, is quite independent of any assumptions as to the nature of the current, or of the circuit, the power given to which it is desired to measure, and it has the further great advantage that the only measuring instrument required is the ordinary alternate-current voltmeter of commerce.

In series with the circuit ab (Fig. 1), the power given to which we desire to measure, connect a non-inductive resistance bc of r ohms.

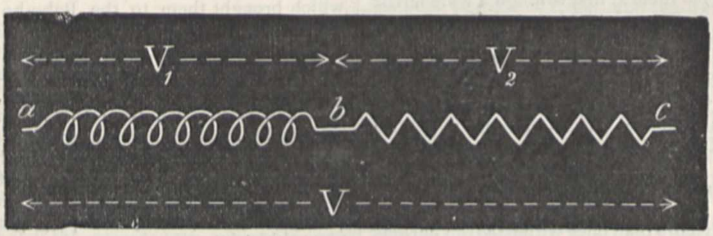

Fig. 1.

Let V_1, V_2, and V be the readings of the voltmeter when applied between a and b, b and c, and a and c respectively; then, if W be the mean watts supplied to the circuit ab, we have in all cases, whatever the nature of the current, or of the circuit ab—

$$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

For, let v_1, v_2, and v be the instantaneous values of the P.D. between a and b, b and c, and a and c at some moment t, then

$$v = v_1 + v_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If a be the current in amperes flowing through the circuit at time t, then av_1 equals the watts w given to ab at that time. But

$$a = \frac{v_2}{r},$$

since the resistance bc is non-inductive;

$$\therefore w = \frac{v_1 v_2}{r}.$$

Then, squaring (2), we have—

$$v^2 = v_1 + 2v_1v_2 + v_2^2;$$

$$\therefore w = \frac{1}{2r}(v^2 - v_1^2 - v_2^2).$$

As this equation is true at every moment, it must also be true for the mean values of w, v^2, v_1^2, and v_2^2.

So that

$$\int_0^T wdt = \frac{1}{2r}\left(\int_0^T v^2dt - \int_0^T v_1^2dt - \int_0^T v_2^2dt\right),$$

and

$$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2),$$

which is the equation given above.

If the resistance of bc be not known, or if there be any fear that it may be changed by the passage of the current, then an

[1] This method was simultaneously arrived at independently by Prof. Fitzgerald.

[1] We may mention that an investigation on quadrant electrometers has been going on from time to time at the Central Institution for the last five years, and we had hoped to have communicated the complete report long before this to the Royal Society.

ammeter (an alternate-current ammeter, of course, if alternate currents be employed) can be inserted in the circuit. Let the reading of this ammeter, which represents the square root of the mean square of the current be A, then, for r in (1) we may substitute V_2/A, or

$$W = \frac{A}{2V_2}(V^2 - V_1^2 - V_2^2) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

When employing this last formula, the non-inductive resistance *bc* may be that offered by incandescent lamps, since there is no objection to the resistance varying with different mean strengths of the current employed.

This voltmeter method of measuring power was arrived at quite independently of the electrometer method referred to above, but an examination of the electrometer method shows that it is practically equivalent to simultaneous measurements of three P.Ds.

An analysis of the equation (1) shows that the value of the non-inductive resistance r, which it is best to adopt in order to reduce to a minimum the error in W arising from errors in the voltmeter readings, is such that the potentials V_1 and V_2 are equal to each other. It can also be shown that the percentage error in estimating the power W due to errors in the voltmeter measurements arising either from faulty graduation of the scale, or from inaccurate readings, is from four to five times the percentage error of a single reading of the voltmeter.

As all instruments that are graduated for measuring the square root of the mean square of an alternating P.D., such as a hot-wire voltmeter, an electrostatic voltmeter, &c., really measure the mean square and not the square root of the mean square directly, it would be better, if such an instrument were to be employed for the method of measuring power described in this paper, that it should be graduated in mean squares of P.Ds. and not in the square roots of the mean squares. In that case the probable percentage error in the measurement of power by the method would be from 2 to 2·5 times the error in the measurement of each of the P.Ds.

It is, of course, clear that these errors to which we have been referring are not errors in any way essential to the method proposed for measuring power, since by the employment of an accurately graduated voltmeter, by exercising care in taking the readings, and, if necessary, by repeating the measurements two or three times and taking the means of the observations, the power can be measured to any degree of accuracy desired.

As in practical cases the sum of the two potentials V_1 and V_2, will not often be much in excess of V, we may conveniently express the true power W in the following way.

If A is the current in *ab* (Fig. 1) as read by an alternating current ammeter, the apparent power absorbed by *ab* is

$$V_1A.$$

The true power W, when V_2 is made equal to V_1, can be shown to be

$$W = \left(1 - 2y + \frac{y^2}{2}\right)V_1A,$$

where

$$y = \frac{V_1 + V_2 - V}{V_1},$$

or as y is usually a small number,

$$W = (1 - 2y)V_1A.$$

Thus the error made in assuming that V_1A represents the true power is 8 per cent. if $(V_1 + V_2 - V)$ is 4 per cent. of V_1, also if, due to unsteadiness of the currents, or to error in the voltmeter readings, the value of $(V_1 + V_2 - V)$ is uncertain to the extent of 1 per cent. of V_1, the uncertainty in estimating W is twice this, or 2 per cent.

III.—The method we have just described is well adapted for measuring the power supplied to an alternating current arc lamp, and is, moreover, likely to be of service in investigating the phenomena of the alternating current arc. Three of our senior students, Messrs. Kolkhorst, Thornton, and Weekes, have made a number of experiments on arc lamps by the use of this method, and from their experiments it would appear that the quality of the carbon employed affects materially the difference in phase between the currents passing through the arc and the P.D. between the carbons. If the arc be quite steady and only give out the rhythmic hum that accompanies a well-formed arc, such as can be obtained with cored carbons of good quality, the arc appears to act practically as a simple resistance, but if the arc be maintained between uncored carbons of poor quality, and be hissing, there is considerable difference in phase between the current and the P.D. between the terminals; further, the experiments show that the current is very far from being a sine function of the time, although produced by a dynamo whose E.M.F. normally follows a harmonic law.

In addition to the difference of phase of P.D. and current that may be produced in the arc itself, there is the electro-magnet to be considered, by which the distance between the carbons is usually regulated in arc lamps. This electro-magnet will introduce lag between the P.D. at the terminals of the lamp and the current passing through the electro-magnet and the arc in series; and hence, even although the arc be perfectly steady, we find, even in the case of a Brush lamp especially intended for alternate currents, that the true power supplied to the electro-magnet and arc is 20 per cent. less than the product of the readings of the ammeter and the voltmeter attached to the lamp terminals, and which gives the square root of the mean product of the squares of the current and P.D.

If, however, the arc be between common carbons and be hissing, the difference, we find, is much greater. With cored carbons this Brush lamp requires a P.D. of about 35 volts to be maintained between its terminals, but if these cored carbons be replaced by common carbons and the arc be hissing, the P.D. between the terminals of the lamp at once rises to 45 or even 50 volts, although the current passing through the lamp and the amount of light given out remain practically as before. And then we find that the true power supplied to the lamp may be only one-half of the square root of the mean product of the squares of the current and P.D., so that the readings of the ammeter and voltmeter alone make the apparent power twice as great as the true power.

For the purpose of easily estimating the ratio of the true to the apparent power supplied, formula (3) may be thus written—

$$W = AV_1\left\{1 - \frac{(V_1 + V_2 - V)(V_1 + V_2 + V)}{2V_1V_2}\right\} \quad . \quad . \quad (4)$$

from which we see that the expression in the brackets represents the ratio of the true to the apparent power supplied to the lamp or other circuit *ab* (Fig. 1). Hence the percentage error made in assuming that the power supplied to any circuit was the product of the ammeter and voltmeter readings would be in all cases, whatever the nature of the current or of the circuit,

$$100\frac{(V_1 + V_2 - V)(V_1 + V_2 + V)}{2V_1V_2} \quad . \quad . \quad . \quad . \quad (5)$$

The following are samples of the results obtained with a hand-regulated lamp, there being no electro-magnet at all in series with the arc (Fig. 2). The carbons were not cored, and the arc was hissing. The frequency was maintained at 200 periods per second.

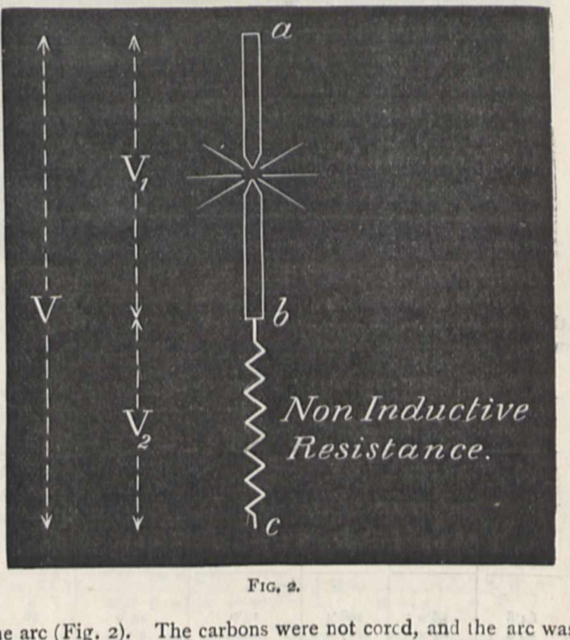

FIG. 2.

Table I.

Square root of mean square					
Of P.D. in volts between			Of current in amperes.	Percentage error in estimating power formula (5).
a and b. V_1.	b and c. V_2.	a and c. V.	A.	
55·0	60·0	108·0	12·3	24·0
45·4	75·4	107·3	11·8	45·8

For the purpose of obtaining an idea of ϕ, the angle of phase difference produced by the hissing arc, between the current and the P.D., we may assume that the P.D. and current are sine functions of the time; then, as may be easily proved,

$$\cos \phi = \frac{V^2 - V_1^2 - V_2^2}{2V_1 V_2} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and the values of ϕ for the two tests given above come out as 40° 20′ and 57° 10′. It will, of course, be observed that this assumption of a harmonic law for the P.D. and current for the purpose of obtaining some idea of the value of ϕ, in no way affects the generality of the method for the measurement of the power, since this is based on no such assumption.

The following are samples of the results obtained with a Brush alternate-current lamp regulated by an electro-magnet (Fig. 3),

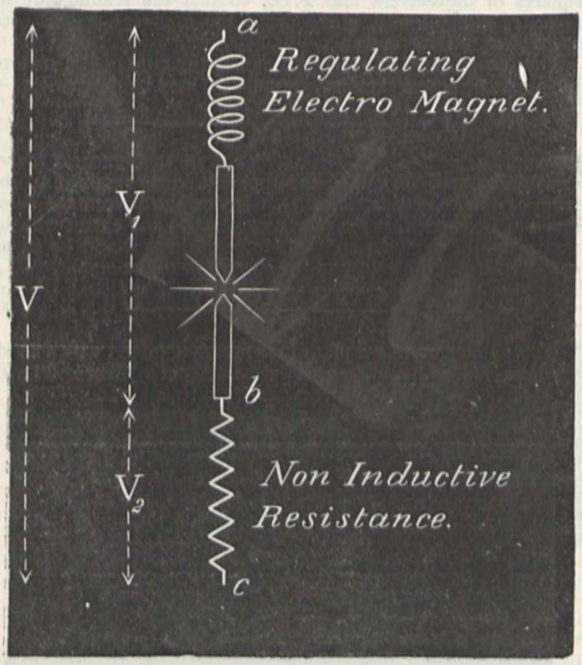

Fig. 3.

the carbons not being cored, and the arc hissing. The frequency was maintained at 200 periods per second.

Table II.

Square root of the mean square				Percentage error in estimating power formula (5).	Lag between current and P.D.
Of P.D. in volts between			Of current in amperes.		
a and b V_1.	b and c. V_2.	a and c. V.			ϕ.
64·8	58·0	108·4	13·0	44·0	56° 0′
59·8	64·2	107·4	12·0	50·5	60 20
55·0	67·3	107·4	10·6	47·0	58 30

The experiments already described tell us that a hissing arc may cause a considerable phase difference between the P.D. and the current, but they do not enable us to decide whether such an arc causes the current to lag behind the P.D., or to lead in front of it. To decide this point—that is, to decide whether a hissing arc acts like an inductive coil, or a condenser—a variety of experiments were made by putting induction or capacity in series with the arc. The following gives the result of one such experiment:—In series with a hand-regulated lamp (and, therefore, containing no electro-magnet), was placed a condenser of 89 microfarads (Fig. 4). Uncored carbons were used, and they were adjusted so that the arc was very short at first; the carbons were then not touched, and, as they burnt away, the arc grew longer and longer until it finally went out. The frequency was maintained at 200 periods per second.

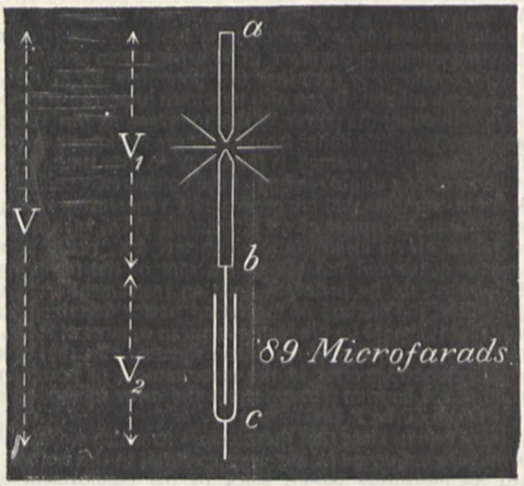

Fig. 4.

Table III.

E.M.F. of dynamo in volts.	Square root of mean square				Sum of $V_1 + V_2$.	Lag between current and P.D.
	Of P.D. in volts between			Of current in amperes.		
	a and b. V_1.	b and c. V_2.	a and c. V.	A.		ϕ.
59	35·4	89·0	72·3	12·0	124·4	129°
	38·0	92·0	73·3	12·5	130·0	133
	51·2	104·5	74·3	14·0	155·7	135
	69·2	86·5	67·5	13·4	155·7	131

Comparing V with the E.M.F. of the dynamo, we see that the arc and the condenser together acted as a condenser on the whole; but, comparing V with $V_1 + V_2$, we see that the arc acted as an induction and not as a capacity.

Calculations from the measurements made on the assumptions that the arc acts like an induction coil, and that the current follows a simple sine law, show that the inductance of the arc itself is as great as that of the regulating electro-magnet used in the lamp. When, however, the inductances of the arc and electro-magnet in series is observed, it is found to be less than the sum of the two inductances. This shows conclusively that the current does not vary according to a simple sine law.]

Linnean Society, April 2.—Prof. Stewart, President, in the chair.—The Rev. Prof. Henslow exhibited specimens of *Oxalis cernua*, Thunberg, a native of the Cape of Good Hope, and gave an interesting account of its introduction into the countries bordering the Mediterranean and the Canaries and Madeira, tracing its present northern distribution, so far as he had been able to ascertain it. A discussion followed, in which Messrs. A. W. Bennett C. B. Clarke, W. Bateson, and B. D.

Jackson took part.—Mr. A. B. Rendle, having examined the specimens of "Monchona" exhibited by Mr. Christy at a previous meeting, expressed the opinion that this trade product was the preserved fruit of a palm, belonging to a species apparently undescribed. It was stated somewhat vaguely by the importer to have come from the South Pacific.—Mr. Rendle also exhibited another specimen of an orange within an orange, which differed from that shown at a former meeting in that the inner orange possessed a rind, and was not entirely enveloped by the outer one.—The President exhibited an abnormal specimen of a butterfly (*Gonepteryx rhamni*) possessing five wings, or two hinder wings on one side.—Mr. W. Bateson then gave the substance of a paper by himself and Miss A. Bateson on variations in floral symmetry of certain plants with irregular corollas. He described the variations in number of parts and of symmetry occurring in the flowers of *Gladiolus*, *Veronica*, *Linaria*, and *Streptocarpus*, and showed that, although in these varieties there is considerable departure from the normal form, yet the resulting variety is often as definite as the normal form, and not less perfect in symmetry. It was suggested that the variations by which specific forms of symmetry are produced may also be thus distinct, and not of necessity involving transitional forms; and, for example, that the process by which the 4-petalled symmetry of *Veronica* arose from that of a 5-petalled ancestor was perhaps similar in kind to that by which the 3-petalled variety of *Veronica* is formed from the type, transitional forms being in such cases rare, or even absent. An interesting discussion followed, in which the President, Prof. Henslow, Messrs. C. B. Clarke, and A. W. Bennett took part.—The Secretary then read a paper by Mr. H. N. Ridley, of Singapore, on two new genera of orchids from the East Indies.

Zoological Society, April 7.—F. Du Cane Godman, F.R.S., Vice-President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of March; and called special attention to a young example of the Ounce or Snow-Leopard (*Felis uncia*), new to the collection, and to a Small-clawed Otter (*Lutra leptonyx*) from India, being the second specimen of this Otter acquired by the Society; also to a specimen of a Lhuys' Impeyan (*Lophophorus lhuysi*) from Szechuen, Western China, obtained by Mr. A. G. Pratt, during his recent visit to that country, being the first example of the species that has reached Europe.—The Secretary exhibited the drawing of a female Antelope (*Tragelaphus gratus*), with a young one, now living in the Zoological Garden, Amsterdam, which had been obligingly sent to him by Heer C. Kerbert, the Director of that Garden.—The Secretary exhibited (on behalf of Mr. W. L. Sclater, Deputy Superintendent of the Indian Museum, Calcutta) a specimen of a Duck, apparently a hybrid between the Mallard (*Anas boschas*) and the Gadwall (*A. strepera*), which had been lately obtained in the vicinity of Calcutta.—Mr. T. D. A. Cockerell read a paper on the geographical distribution of Slugs. The author divided the known Slugs into six families: Succineidæ, Vaginulidæ, Arionidæ, Limacidæ, Testacellidæ, and Selenitidæ, under which he grouped fifteen sub-families. The Janellidæ were reduced to a sub-family of Succineidæ, and the generic nomenclature of the whole group was revised, two new genera and one new sub-genus being named. The Philomycidæ were made a sub-family of the Arionidæ. The distribution of each sub-family, and of all recognizable genera, was discussed in some detail. Under the *Veronicellinæ* a new sub-genus *Imerinia*, from Madagascar, was indicated.—A communication was read from Dr. Alcock, Surgeon-Naturalist to H.M. Indian Survey steamer *Investigator*, containing a description of *Saccogaster maculatus*, a viviparous Bathybial Fish from the Bay of Bengal.—Prof. F. Jeffrey Bell read some observations on *Bathybiaster vexillifer*, a Star-fish originally described by Sir Wyville-Thomson, of which the typical specimen had lately been received by the British Museum.—Mr. G. A. Boulenger gave an account of the Siluroid fishes obtained by Dr. H. von Ihering and Herr Sebastian Wolff in the Province of Rio Grande do Sul, Brazil.—Mr. F. E. Beddard read a paper giving some account of the anatomy of the Patagonian Cavy (*Dolichotis patagonica*) from specimens recently living in the Society's Gardens.

Mathematical Society, April 9.—Major MacMahon, R.A., F.R.S., Vice-President, in the chair.—Major MacMahon (Mr. J. J. Walker, F.R.S., taking the chair *pro tem.*) read a paper on the analytical forms called trees, with applications to the combinations of certain electrical quantities and to the compositions of multipartite numbers. A discussion followed, in which Mr. Kempe, F.R.S., Mr. S. Roberts, F.R.S., and Mr. J. Hammond took part.—Mr. Kempe spoke on the flaw in his proof of the map-colour theorem which had been pointed out by Mr. P. J. Heawood (see Appendix to vol. xxi. of the Society's Proceedings), and stated that he was still unable to solve the problem fully.—Mr. Tucker (Hon. Sec.) communicated a paper by Mr. Culverwell on compounded solutions in the calculus of variations.

EDINBURGH.

Royal Society, April 6.—The Hon. Lord Maclaren, Vice-President, in the chair.—Sir Douglas Maclagan read an obituary notice, by the Right Hon. Lord Moncrieff, of Prof. Campbell Swinton.—Prof. Crum Brown read a paper, written by himself and Dr. James Walker, on the synthesis of dibasic acids by means of electrolysis. In a previous paper on this subject the authors described the behaviour of the ethyl-potassium salts of normal dibasic acids on electrolysis. These they found to yield always the diethyl esters of normal acids of the same series. In the present paper, extending their investigation to acids with side chains, they give an account of the alkyl derivatives of succinic acid as obtained by the electrolysis of ethyl-potassium methyl-malonate and ethyl-potassium ethyl-malonate. The esters formed according to the general equation,

$$2EtO(CO) . R'' . (CO)O = EtO(CO) . R'' . R'' . (CO) . OEt + 2CO_2,$$

are evidently always symmetrical, so that from methyl-malonic acid one might expect to obtain symmetrical dimethyl-succinic acid,

$$[2EtO(CO) . CH(CH_3) . (CO)O = EtO(CO) . CH(CH_3) . CH(CH_3) . (CO)OEt + 2CO_2].$$

This dimethyl-succinic acid contains two similarly situated asymmetrical carbon atoms, and is thus, like tartaric acid, capable of existence in four isomeric forms—two optically active, and two optically inactive, one of these latter (corresponding to racemic acid) being a compound or mixture in equal proportions of the two opposite optically active acids. As the optically active forms are produced in equal proportions by any purely chemical process from inactive materials, the authors were justified in expecting to obtain, by electrolysis, a mixture of the esters of the two inactive symmetrical dimethyl-succinic acids. The synthesis was conducted in precisely the same manner as in the previous experiments. The authors succeeded in separating and purifying two acids—one, the less soluble, having the melting-point 193° C., the other melting at 120°–121° C. These acids on analysis proved to have the same composition—both corresponding to the formula $C_6H_{10}O_4$—the acid melting at 193° C. being apparently identical with the para-s-dimethyl-succinic acid of Bischoff (melting-point 194° C.), while the other seems to be identical with his anti-s-dimethyl-succinic acid. This conclusion was further confirmed by measurements of the electrolytic conductivity of solutions of the acids. In a similar manner the authors performed the electrolysis of ethyl-potassium ethyl-malonate. As before, they obtained, in the pure state, two acids, one melting at 192° C. with decomposition, the other at 130° C. Analysis showed that these acids have the composition of diethyl-succinic acid, and, from their mode of formation, are symmetrical. These are evidently identical with the para-s-diethyl-succinic acid (melting-point 192° C., with decomposition), and the anti-s-diethyl-succinic acid (melting-point 129° C.) of Bischoff and Hjelt. This conclusion also was further confirmed by measurements of electrolytic conductivity.—Prof. Tait read a paper on the Virial, with special reference to the isothermals of carbonic acid. He showed that the usual mode of writing the equation, with $p(v - \beta)$ as the left-hand member (where the term βp is part of the virial), is incorrect except in the absence of molecular force. The true form of the (approximate) virial equation is

$$p = \bar{p}\left(1 - \frac{(v - \bar{v})^3}{v(v + \alpha)(v + \gamma)}\right) + \left(R + \frac{e}{v + \alpha}\right)\frac{t - t}{v},$$

where $\bar{p}$, $\bar{v}$, t belong to the critical point. A first rough estimate, based on Amagat's recent work, gives for carbonic acid the values $\bar{p} = 72·6$ atm., $\bar{v} = 0·0046$. Andrews long ago carefully determined $t = 30°\cdot9$ C. The approximate values of the other constants are $\alpha = 0\cdot001$, $\beta = 0\cdot0008$, $R = 0\cdot00371$, and $\epsilon = 0\cdot000021$. With these, the above formula gives fair representations of the isothermals from 0° C. to 100° C., for ranges of pressure from 1 to 500 atm. These are, however, to be regarded as provisional values only. Further numerical work is required to determine them more exactly. The formula above is based on the assumptions (1) that the particles are hard spheres, and (2) that the absolute temperature is measured by the average energy of a *free* particle; and its agreement with experiment is regarded as strong evidence in favour of the truth of the second of these assumptions; which, in its turn, throws strong light upon the nature of the liquid, and even of the solid, state.

PARIS.

Academy of Sciences, April 6.—M. Duchartre in the chair.—On a system of equations from partial derivatives, by M. Émile Picard.—Transformation *in vitro* of lymphatic cells into *clasmatocytes*, by M. L. Ranvier. It is shown that the lymphatic cells of the frog may be transformed into ramified, immobile cells—that is, into *clasmatocytes*—by making a preparation of the peritoneal lymph and keeping it in a glass cell at a temperature of 25° C. for one hour.—On vaccination by minimum doses of vaccinating matter, by M. Ch. Bouchard. The results of numerous experiments indicate that vaccinating matters act efficaciously when the amount employed is only a small fraction of a milligram. In one experiment complete immunity was obtained by the total injection of 0·026 c.c. of the culture per kilogram of the subject.—Interpretation of the fire-ball painted by Raphael in his picture the "Madonna di Foligno," by M. Daubrée (see NATURE, vol. xliii. p. 500, and *American Journal of Science*, March 1891).—The law according to which the sum of the distances from the moon to two certain stars varies in the function of time, by M. L. Cruls.—New nebulæ discovered at Paris Observatory, by M. G. Bigourdan. This is a continuation of lists previously given, and contains a description of fifty-five new objects situated between nine and sixteen hours of right ascension.—Observations of the asteroid (308) discovered at Marseilles Observatory with the Eichens equatorial, by M. Borrelly. Observations for position were made on March 31 and April 1 and 4.—On the theory of surfaces applicable to a given surface, by M. J. Weingarten.—On the theory of applicable surfaces, by M. E. Goursat.—On an analytical problem which is connected with dynamical equations, by M. R. Liouville.—On regular continuous fractions relative to e^x, by M. H. Padé.—On the mode of vibration of membranes, and the *rôle* of the thyro-arytenoidean muscle, by M. A. Hubert.—Preparation and properties of iodide of boron, by M. Henri Moissan. (See Notes, p. 568.)—On a new compound of molybdenum, by M. E. Péchard. A description of permolybdic acid, Mo_2O_7, is given.—On a new method for the separation of iron from cobalt and nickel, by M. G. A. Le Roy. An electrolytic method is proposed for the separation of iron from cobalt and nickel.—On the asymmetry and the production of the rotatory power in the chlorides of the compound ammoniums, by M. J. A. Le Bel. The author shows that when four alcoholic radicals are substituted for the hydrogen in ammonium chloride, the molecule appears to attain an invariable geometrical form. This is experimentally proved by the existence of isomers and the appearance of rotatory power when these four radicals are different.—On the nitro-derivatives of dimethyl-ortho-anisidine, by MM. E. Grimaux and L. Lefevre.—On the transformation by heat from campho-sulpho-phenols to homologues of ordinary phenol, by M. P. Cazeneuve.—On terebenthene, by M. Raoul Varet.—On ethyl malonate, and ethyl-potassium malonate, by M. G. Massol.—On the micro-organisms found on grapes, and on their development during fermentation, by MM. V. Martinand and M. Rietsch.—Contribution to the study of the bleaching effect of the air, by MM. A. and P. Buisine.—Law of position of nervous centres, by M. Alexis Julien.—New observations on the oceanic sardine, by M. G. Pouchet.—On the supposed crane of Moctezuma II., by M. E. T. Hamy.—On the existence of tuffs of andesite in the flysch of La Clusaz (Upper Savoy), by M. P. Termier.—On the phenomena consecutive to the alteration of the pancreas determined experimentally by an injection of paraffin in the *Wirsung* canal, by M. E. Hédon.—On the phenomena consecutive to the destruction of the pancreas, by M. E. Gley.—Chemical researches on microbian secretions: transformation and elimination of the nitrogenous organic matter by the pyocyanic bacillus in a medium of a given culture, by MM. Arnaud and A. Charrin.

STOCKHOLM.

Royal Academy of Sciences, March 11.—On symbiosis as causing accessory secretions in the shells of marine Gastropoda, by Dr. Carl Aurivillius.—Researches on the amount of blood expelled from the heart, by Prof. Tigerstedt.—On pendulum observations made in the mines of Sala during 1890, by Prof. Rosén.—A report on a foreign tour undertaken to study constructions suitable for maritime purposes, by Herr Nystedt, marine engineer.—On the respiration of the Algæ, by Miss H. Lovén.—On the hydrography of the fiord of Gullmar, by Miss A. Palmqvist.—Observationes mycologicæ; i. de genere Russula, by L. Romell.—On the African species of the genus Xyris, by Dr. A. Nilsson.—An elementary demonstration of the fundamental proposition of the equation theory, by Dr. E. Phragmén.—On the cyclic system of Ribaucour, by Prof. Bäcklund.—The radiation of the clouds around the thermometric minima, by Dr. H. Hamberg.—Geological observations on Snaefellenesand in the environs of the Faxebay in Iceland, by Dr. Th. Thoroddsen.—Derivation of a formula within the mathematical statistic, by Dr. G. Eneström.—Observations on the ephippiæ or the hivernal egg-capsules of *Daphnia pulex*, by Baron G. C. Cederström.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A Dictionary of Applied Chemistry: Prof. T. E. Thorpe; vol. ii. (Longmans).—The Missouri Botanical Garden (St. Louis).—A Treatise on Plane Trigonometry: E. W. Hobson (Cambridge University Press).—Elementary Lessons in Heat, Light, and Sound: Prof. D. E. Jones (Macmillan and Co).—The "Progressive" Euclid, Books 1 and 2: A. T. Richardson (Macmillan and Co).—Magnetic Observations at the U.S. Naval Observatory, 1888 and 1889: J. A. Hoogewerff (Washington).—The Elements of Statics and Dynamics; Part 2, Elements of Dynamics: S. L. Loney (Cambridge University Press).—Traité Élémentaire d'Électricité: J. Joubert; 2me. edition (Paris, G. Masson).—The London and Middlesex Note-book (E. Stock).—Elementary Chemistry: W. J. Harrison (Blackie).—Familiar Objects of Every-day Life: J. Hassell (Blackie).

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