THURSDAY, APRIL 6, 1893.

## MATHEMATICAL ELASTICITY.

*A Treatise on the Mathematical Theory of Elasticity.* By A. E. H. Love, M.A., Fellow and Lecturer of St. John's College, Cambridge. Vol. I. (Cambridge: University Press, 1892.)

MR. LOVE'S treatise is the necessary complement to Todhunter and Pearson's "History of the Theory of Elasticity," in which an abstract is given of all the most important original memoirs bearing on this subject, arranged in historical order.

But the student who wishes to make himself acquainted with the works of these original authorities, by the guidance of Todhunter and Pearson's History, will find the necessity of an acquaintance with Mr. Love's work as an introduction to the elements and to the notation of the subject of elasticity.

Mr. Love has prepared an elegant and modern artillery of analysis; and he is not afraid to fire off his guns. To pursue the simile, there is no fear of the subject being obscured in the smoke of his own guns—in these days of smokeless gunpowder.

The size of the book is kept within reasonable dimensions, compared with the scale of a continental treatise, by leaving the heaviest parts of the analysis as exercises to be worked out by the trained mathematical student, to whom the work is addressed.

The author says in the preface, "I have not thought it advisable to introduce collections of examples for practice." But such collections do not exist, and the author would find it as formidable a task as that he has already carried out to attempt to construct the examples himself. In the present state of his subject any really novel example would be worthy to take rank as a new and independent theorem.

The examples which we see around us of the physical and industrial applications of the Theory of Elasticity are the best check in existence to keep the subject from becoming a mere development of pure mathematics, with such generalisations as to space of $n$ dimensions, and based upon physical laws adopted merely because of the analytical elegance they confer, quite apart from any experimental verification.

The first five chapters are occupied with the general theory, including the analysis of strain and stress, stress-strain relations, the strength of materials, and a number of general theorems. In the analysis of strain the method of Thomson and Tait's "Natural Philosophy" has been followed, beginning with the geometrical and algebraical theory of finite homogeneous strain, deducing thence the physical state of infinitesimal strain. Hooke's law, made such a mystery of by its inventor, now becomes a necessary consequence of the expansion by Taylor's theorem of the stresses as functions of the displacements and strains, neglecting power above the first or second; and the law receives ample experimental justification in the observed isochronism of the small vibrations of elastic bodies, as exhibited by the musical notes they give out.

In the treatment of the bending of a beam and the torsion of a cylinder in Chapter VI., Saint-Venant's method has been followed, and the warping and distortion of the cross-section carefully investigated and illustrated in fig. 10, p. 156.

This warping effect is well known to engineers, though hitherto generally ignored in the mathematical treatment, as impairing the sweet simplicity of a bending moment and consequent proportional curvature resulting only from the extension and compression of the fibres, thus ignoring the shearing stresses called into play. We can now begin to perceive the reason why a beam is so much stronger and stiffer than it ought to be according to the ancient theory.

In the investigation of the torsion of a cylinder, where cross-section is a rectangle, the analysis of Thomson and Tait has been closely adhered to. Dr. Ferrers, the Master of Gonville and Caius College, has made this analysis more complete and symmetrical, and has exhibited the hydrodynamical analogies more clearly, by employing a pair of Fourier series, one proceeding by sines and cosines of multiples of $x$, and the other of $y$; each series representing separately the motion or displacement corresponding to a simple shear of the rectangular section. The elliptic function interpretation of this pair of series, in which the corresponding moduli are obviously complementary, is very interesting, but has not been pursued by Mr. Love.

Now that Prof. Karl Pearson has dedicated the first part of the second volume of the History to the "Memory of Saint-Venant," the political cloud, vaguely described in M. Bertrand's recent *éloge* of Chasles, which overshadowed Saint-Venant's official career, is clearing off, and full tribute is beginning to be paid in France to the great advances due to him.

Lamé, too, like Saint-Venant, appears to have lived in official neglect, although his method of Curvilinear Coordinates, expounded in Chapter VII., has been a powerful analytical engine for the solution of elastical problems, and his "Théorie de l'Élasticité" is a standard text-book to the present day.

The solution of the elastic deformation of a sphere, treated in Chapter X., is also due to Lamé. Mr. Love applies his analysis to the consideration of the effect of a flaw in the shape of a spherical cavity, and shows that in this case the engineer's factor of safety of 2 is the theoretically correct factor.

The most important application on a large scale of the analysis of the elastic deformation of a sphere is the investigation of the effective rigidity of the earth, considered as an elastic solid, under the action of its own gravitation, and slightly disturbed by the rotation and the tide-producing forces. Elaborate calculations and observations have been carried out by Prof. G. H. Darwin; if we could observe and measure the bodily tides in the earth, an estimate of its rigidity could be obtained. Mr. Love gives the numerical results corresponding to mean rigidities equal to those of steel and glass.

Mr. Chree's valuable investigations of the strain produced by rotation in an elastic circular disc, in a sphere or an ellipsoid, are introduced here, and receive careful analysis and interpretation.

Chapter XI. treats of the vibrations of a sphere. The free vibrations have been completely worked out by Prof. Lamb. In the forced vibrations the lag or change of phase is the interesting subject of inquiry, as showing to what extent the "equilibrium theory" of the bodily tides of the earth, considered in the preceding chapter, can be adopted as a working theory.

Lord Kelvin has shown how the inertia of a pendulum appears reversed in sign if the point of support is actuated by a vertical vibration, when the forced and free periods are as two to one; but when the periods are made in the ratio of three or four to one, the equilibrium theory can be adopted. This principle has been employed recently by Sarrau and Vieille in the measurement of powder pressures by means of spring gauges; the free period of the spring is so adjusted in comparison with the period of the applied pressure, so that the vibrations of the spring do not make their appearance, and the indications of the gauge are the same as those for an equal statical pressure, steadily applied.

Valuable work in the discussion of particular problems of a somewhat general nature has been carried out by the late Prof. Belti, of Pisa, and continued by his disciple Cerruti; particularly also by M. Boussinesq, in his theory of "local perturbations" in an elastic solid bounded by a plane, as illustrated, for instance, in the deflection produced in a sheet of ice by a man standing on it; these questions occupy Chapters VIII. and IX.

The applications of conjugate functions in Chapter XII. introduce some interesting problems. The book concludes with the consideration of an elliptic cylinder, turned through a small angle. Something appears wanting here, as the balancing couples on the interior and exterior confocal ellipses are not brought into evidence. When the exterior ellipse becomes indefinitely large the stresses over it are evanescent, but their resultant is a finite couple. So, too, when the inner ellipse becomes the line joining the foci; in this case the Jacobian $h$ becomes infinite at the centre, and the displacements $u$ and $v$ at this point require closer investigation.

It is unfortunate, as Maxwell remarked, that we have no space functions corresponding to the conjugate functions of a plane. But by the rotation of these conjugate plane curves about an axis, Waugerin has obtained a system of space co-ordinates, suitable for application to certain surfaces of revolution, and he, Mr. Hicks, and Mr. W. D. Niven, have worked out the analysis completely for certain quadric surfaces, cones, and tores.

In the questions considered in this first volume the forces which produce the elastic displacements are of moderate amount, so that the proportionality of stress to strain may be taken as true, and they act as distributed forces throughout the solid, such as gravity and the *forces of inertia* introduced by vibrations.

Mr. Love measures these forces per unit mass, and not per unit volume, as in Thomson and Tait's "Natural Philosophy," so that the component forces appear as $\rho X$, $\rho Y$, $\rho Z$, qualified by $\rho$, the density as a factor.

Cases might arise, however, say in a dynamo, where some of the forces, the forces of inertia and gravity, would be measured per unit mass, and the others, the electromagnetic forces, per unit volume; for this reason the Thomson and Tait method of measurement appears preferable, as the factor $\rho$ can be inserted where required.

The difficulties of constructing a rational theory will turn up in the second volume, when the question of the elastic equilibrium of a lamina has to be considered, in which the stresses are due to an applied finite pressure on one side of the lamina. Mr. Basset has performed a valuable service in pointing out the insufficiency of preceding methods for constructing a theory of such an important practical question as the collapse of boiler flues (*Phil. Mag.*, September, 1892), and he might have added of the Bourdon gauge. We await with interest Mr. Love's contribution to this delicate and baffling part of the Theory of Elasticity.

In the preface of the "Treatise on Solid Geometry," by Frost and Wolstenholme, the authors, after thanking the proof-readers for their trouble, conclude by "expressing their regret that they have not escaped a large number of errors, which it will be punishment enough to them to see tabulated in an adjoining page."

Where the critic has also been a proof-reader he lays himself open to this ambiguous acknowledgment, if he points out any misprints; but we are pleased to find that the present volume, on careful re-examination, appears to be very clearly and correctly printed.

A. G. GREENHILL.

## BIOLOGY AND THE MEDICAL STUDENT.

*Text-book of Elementary Biology.* Introductory Science Text-book Series. By H. J. Campbell, M.D. (London: Swan Sonnenschein and Co. New York: Macmillan and Co., 1893.)

THIS volume of 266 pages octavo is an ultra-elementary one, subdivided into a first part of 155 pages, which deals with generalities of plant and animal morphology and physiology, together with the principles of classification, and into a second of 111 pages devoted to the consideration of certain type organisms. With the exception of the dog-fish, which the author dismisses in four short pages, the said types are those of the examination syllabus of the Conjoint Board of the Royal Colleges of Physicians and Surgeons; and the fact that the book is the first one which has been written up to that standard invests it with a special interest. It is illustrated by 136 borrowed woodcuts, some of which are very poor and antiquated, while others are defective. Its author shows himself to be possessed of a considerable power of discretion, and his book is clear and attractive in style. It is, however, a pure compilation, for the most part from well-known text-books, as is only too apparent in certain gross errors transcribed, for example, that of the assertion that the Monotreme brains are "not convoluted"; its only novelty lies in the judicious introduction of concise and useful historical *résumés*, giving the dates, names, and achievements of epoch-making investigators. Trivial errors abound, and controversial matters of the moment are here and there dogmatically introduced, as though finally established; to wit ($a$) the allusion (pp. 39 and 145) to the ectoblastic origin of the segmental duct, which, so far as it may be to-day regarded as an undisputed fact, rests upon Van Wijhe's discovery of a dividing nucleus connecting it with the parent epiderma, and ($\beta$) the assumed conjugative reproduction of Amœba (p. 160). Conversely it is refreshing to find that in this, a most elementary work, the pulmonary sacs of spiders are alluded to as "fantracheæ" (p. 105) and the lung hooks of scorpions as "chambered tracheæ" (p. 112). The author distinguishes between more general matter printed in large type, and more detailed set up in smaller, pointing out in his preface that "in reading the book for the first time the student is advised . . . to read only" the former. The fact that in some cases a knowledge of the details in question is indispensable for the appreciation of the broader statements laid down for first reading, somewhat detracts from the utility of the method employed; and in at least one case (two top paragraphs of p. 7) the sentences are so worded that the exclusion of the smaller type involves error and confusion of ideas. One of the most characteristic features of the work is its marked brevity. "A general review of the Mammalia" is essayed in eleven pages, while the "Infusoria" are despatched in one line and a word (but a cross reference to the Vorticella described in full in a subsequent chapter). No wonder then, that for want of due qualification, descriptions of things and conditions in reality individual and special should serve for those general and of broad application (as, for example, the assertion that the spiders as an order have an unsegmented cephalo-thorax, and that "all cells resemble each other when they are first formed"), and that negative characters should be occasionally employed for diagnostic purposes, to the exclusion of others of a positive and more forcible nature but requiring a more detailed declaration (*cf.* the treatment of the limbs of Primates). Some of the more lengthy descriptions are, nevertheless, inadequate and unfortunate, notably that of the sponges, which are defined (p. 85) as "the connecting link between unicellular animals on the one hand and multicellular animals on the other," and whose complex structure is illustrated by a diagram unlike anything in nature. In dealing with the vertebrate reproductive system and cloaca, the author has so mixed up details and definitions that his statements are misleading, contradictory, and in part erroneous (*cf.* pp. 155 and 264, and 135, 153, 252, and 256). In dealing with the lower plants, the existence of sieve-tubes in the marine algæ (*Macrocystis*) might with advantage be alluded to as an all-important elementary fact, and the definitions of the Thallophyta and the Pteridophyta might well be modified accordingly. Minor errors and deficiencies, such as the implied absence of sensory cells in the hydra, the too-frequent employment of the adjective "horny" in allusion to structures having no such constitution (*cf.* especially pp. 102 and 192), the confusion between the "wing" and patagium, and the definition of important orders and families in terms which in their scantiness convey no adequate meaning, will doubtless be duly corrected and made good. This notwithstanding, the book has many good points, and its clearness of style is a high recommendation; its greater subdivision, if amplified and supplemented by way of introduction of great groups not even named in the present edition (*e.g.* the Brachiopoda and Polyzoa), might be worked up into a generally serviceable volume.

The lesser subdivision of the volume chiefly merits attention for having been avowedly compiled for the examinees of the conjoint medical board above alluded to. The programme is as follows:—Amœba (5 pp.), Yeast Plant (3 pp.), Protococcus and Glœocapsa (6 pp.), Bacteria (6 pp.), Vorticella (7 pp.), Gregarinæ (5 pp.), Hydra (9 pp.), the Liver Fluke (11 pp.), Tape Worms (21 pp.), Nematoda (12 pp.), the Leech (11 pp), General Review of the Mammalia (11 pp.) = 107 pp. in all, of which 66 are devoted to animal parasites—a veritable diet of worms! We know not upon what principles this *régime* has been prescribed; but when it is considered that the doctrine of phagocytosis, which has of recent years done more than all else to advance and revolutionise medical science, is the direct outcome of comparative biological inquiry, and that its founder is a non-medical man, we confess to a feeling of astonishment. The programme itself savours of the "Technical Education" bogie of our times, than which no greater deception has ever existed. The principles of an elementary scientific training must be the same for the medical man and the mechanician, the philosopher and the plumber. Natural laws and ultimate principles are for all time and unalterable; and experience shows that the medical student whose elementary biological training embraces a comprehensive structural analysis of some small mammal (if of no lower vertebrate in addition) together with the principles of comparative morphology, working from the tree thus surveyed as a whole through the scattered leaves of his surgical anatomy, emerges a thinking man, rather than a mere pedant, as has been so often the case in the past. The chief value of biological science to the medical student is unquestionably educational. To sink this all-important aspect of his scientific training, in preference for a mere dabbling in helminthology, as we venture to think has been done in the case before us, is to neglect one of the surest safeguards for the future, and to ignore the dictates of common sense based upon experience. The attitude is indicative of a retrogressive return to the days when medicine was the only channel of approach to science, and to that order of things, the lingering relicts of which, still hovering over certain of our English-speaking Universities, to-day bar the way to the employment of all but medical graduates as responsible teachers of science in certain of their medical departments. The time is fast dawning, when in London and other great centres, the preliminary scientific training of the medical student must of necessity be imparted either in central institutions devoted to the purpose, or in no less special ones attached to the medical schools themselves. This work, if it is to be done properly and to the credit of the nation, must clearly be entrusted to trained specialists, whose business it shall be to keep abreast of the times; and by such men the text-books of the future will have to be written. The principles which have called forth the volume now under review, on the other hand, favour a professional monopoly, under which the medical practitioner will tend to usurp the functions of the trained non-medical educationalist, to the detriment of his own calling and the reversion to a well-nigh obsolete constitution. Indications of the exercise of this monopoly are abroad; but we shall be much surprised if, in the bidding for the medical student now rife, it obtains a foothold.

G. B. H.

## THE MORPHOLOGY OF BACTERIA.

*Contribution à l'Étude de la Morphologie et du Développement des Bactériacées.* Par A. Billet, Doct. en Méd., Médécin-Major de 2e classe. (Paris: Octave Doin.)

SINCE the publication of the "Peach-coloured Bacterium," by Prof. Lankester, the subject of the morphology of the bacteria cannot be said to have received much attention from English investigators. The department of bacteriology has to a great extent been monopolised by the physician, who appears to confine himself almost exclusively to the study of the more practical bearings of the subject. It is therefore refreshing to find a surgeon-major devoting his time to a very thorough investigation of bacterial morphology.

Dr. Billet's work dates back from 1885, and was carried on for the most part in the Wimereux Laboratory under the able direction of Prof. Giard. His communications were first published in the *Bul. Sc. de la France et de la Belgique*, and the present work is a collected and revised edition of these. The work consists of some 287 pages, and includes (1) an historical introduction, which, owing to its succinctness and chronological sequence, will be found of great use to the general bacteriologist; (2) a minute description of the life histories of *Cladothrix dichotoma* and *Bacterium parasiticum*, and of two new species named by Dr. Billet, *Bacterium Balbiani* and *Bacterium osteophilum*; (3) a very large bibliographical index embracing some 662 references; (4) a very beautiful series of drawings.

The author briefly sketches the progress of morphology from the time of the doctrine of immutability of Cohn and that of pleomorphism of Prof. Lankester, Cienkowski, and Zopf. He shows how C. Robin (1847), in his wonderfully interesting work, pointed to an affinity between certain bacteria, his *Leptothrix baccalis*, for instance, and certain filamentous algæ, the Leptothrix of Kützing (1843); how, after the lapse of twenty-six years, Prof. Lankester (1873 and 1876), determined, in his well-known *Bacterium rubescens*, the coexistence of micrococcal, bacillary, and spirillar forms; and finally, how the theory of the "form phases" became further elucidated by Cienkowski in 1887 in the "Morphologie der Bakterien," and by Zopf in 1871 in his "Genetische Zusammenhang von Spaltpilzformen." The latter observer describes in the life history of the higher bacteria, coccal, bacteroid, bacillary, vibrio, spirillar, leptothrix, and zooglea forms; the *Clathrocystis roseo-persicina* of Cohn becomes the zooglea phase described in *Bacterium rubescens* of Lankester, or more correctly, of the higher *Beggintoa roseo persicina*. Starting with the above series of form phases, the author ingeniously consolidates and groups them into four stages, viz.:—1. The *filamentous*, in which the bacteria are associated into larger and shorter filaments. 2. The *dissociated* stage in which the elements become free and motile, and assume the well-known coccal bacteroid and other forms. 3. The *interlacing* stage—*état enchevêtré*—where the elements interlace with one another. 4. A *zooglea* stage, in which the elements loose their movements and aggregate themselves into certain definite forms. The author goes on to show how definite and characteristic are these groupings in the case of the organisms which he has examined (see above). He points out that their presence or absence depends upon surrounding conditions—media, temperature, &c. But he further widens the whole question in seeking to show that in the less highly developed bacteria there are traces of the form phases and form groupings of the more morphologically perfect organisms. In this connection he briefly brings together the observations which have been made upon the life history of the lower bacteria. Thus the encapsulation observed in the pneumococci, streptococci, tubercle, and anthrax bacilli, sarcinæ, &c., &c., may correspond to the zooglea stage, for he recognises both pneumococcal, merispomedia, and sarcina forms in his zooglea stage. He regards the zooglea as protective, and forming when the medium is becoming exhausted. We may add that in the animal tissues encapsulation often appears dependent upon the resistance offered by the tissues. He further points out that the zooglea is often pigmented.

In describing the life histories of his bacteria, Dr. Billet makes some interesting remarks. Thus, he is inclined to believe that the cilium of the vibrio form is nothing else than the residuum of the inner coat, and that it is formed during the process of segmentation by a drawing out and attenuation of the inner coat, like, for example, when a glass rod is drawn out in a flame. As many vibrios move about which have no cilia, he agrees with Van Zieghem that the bacterial element has a proper movement of its own, which is not dependent upon a cilium, and he believes that the cilium of the Bacteria is quite a different thing from the cilium of zoospores. He carefully describes the movements of the vibrio forms, and adds that they are greatly accentuated by a powerful light, a point first observed by Engelmann, in his *Bacterium photometricum*. He also states that the passage from the rectilinear forms to the less curved (vibrio) and more curved (spirilla) forms, depends upon the degree of temperature and amount of putrefaction; the greater the latter the more the twisted and appendiculate forms. He concludes by giving the evidence in favour of a relationship between the Bacteria and the Algæ; the relationship appears great in the case of the organisms which he describes, but probably if he had studied Actinomyces he might have similarly found very many points in favour of a relationship with the mycelial fungi.

RUBERT BOYCE.

## OUR BOOK SHELF.

*Introductory Modern Geometry of Point, Ray, and Circle.* By W. B. Smith. (London: Macmillan and Co., 1893.)

THIS work of Prof. Smith's has a "very practical purpose," viz. "to present in simple and intelligible form a body of geometric doctrine, acquaintance with which may fairly be demanded of candidates for the Freshman class" of the Missouri State University. It is shaped on the lines of such modern works as those by Newcomb, Halsted, and Dupuis, to refer to English textbooks only; but it most nearly resembles in some parts the excellent little manual "on congruent figures," by Prof. Henrici. "The work asks to be judged, at least in its name, according to (the) spirit of modern geometry, and not according to the letter."

It is hard at this date to write anything new on the subject of elementary geometry, and for the class addressed by the author it is not desirable, but the well-known facts may be treated in very diverse ways: in this case there is a novelty and freshness which must commend the treatment of them to all intelligent students. Take this "precise definition" of a plane: Take two points A and B and suppose two equal spherical bubbles formed about A and B as centres. Let them expand, always equal to each other, until they meet, and still keep on expanding. The line where the equal spherical bubbles, regarded as surfaces, meet, has all its points just as far from A as from B. As the bubbles still expand, this line, with all its points equidistant from A and B, itself expands and traces out a *plane* as its path through space. Hence we may define the *plane* as the region (or surface) where a point may be, that is, equidistant from two fixed points. . . It is evident that the plane, as thus defined, is reversible. . . The superiority of this definition consists in its not only telling what surface the plane is, but also making clear that there actually *is* such a surface. Thence our author readily derives the notion of the *ray* (anglicè, straight line: a *tract* being a part bounded by end-points).

This manner of illustration occurs repeatedly, and adds, we think, much to the interest of the book.

As a specimen of the mode of proof employed we take what is equivalent to part of Euc. i. 5. *Data.* ABC, an isosceles triangle, AB its base, AC and BC its equal sides (here we may remark the figure is badly drawn: a similar remark applies to figures on pp. 60 and 91). *Proof.* Take up the triangle ABC, turn it over, and replace it in the position BCA. Then the two triangles ACB and BCA have the equal vertical angles, C and C, also the side AC = BC (why?) and BC = AC (why?); hence they are congruent (why?), and the $\angle A = \angle B$.

In the more elaborate proofs there is a larger crop of "whys," and in some cases the interrogation is answered by the author.

The amount of ground covered is considerable, and yet, as we have gone through the whole of the text, it is so clearly opened up that the intelligent student, to whom we have previously referred, should be able to master it all, and successfully grapple with the well-chosen exercises which are arranged in fitting places throughout the book. "These exercises have been chosen with especial reference not so much to their merely disciplinary as to their didactic value, the author being persuaded that quite as good exercise may be f ound in going somewhither as in walking round the square."

We have no hesitation in heartily commending Prof. Smith's introduction to teachers and pupils as an excellent one, and this we vouch, adapting the language of the learned counsel cited by Bailie Littlejohn, *nostro periculo.*

*Primer of Horticulture.* By J. Wright. (London: Macmillan and Co., 1893.)

THIS primer contains the substance of ten lectures delivered by Mr. Wright for the Surrey County Council. Besides the lectures, some sets of questions, asked after the lectures, are given together with the answers to these questions.

The primer is eminently practical, and is sure to prove very useful both to gardeners and to students. It cannot, however, be considered quite free from errors, and a careful revision would increase its value.

Sometimes the text is rather loose.

On p. 54 the word *pistil* is used indefinitely, sometimes meaning the style and at others the whole gynœcium.

Speaking of phosphatic manures on p. 64 the author says:—

"Mineral superphosphate is ground coprolite treated with sulphuric acid.

"Coprolite is antediluvian petrified manure, of which there are large beds in the Eastern Counties. It is fairly active, yet sustaining.

"Thomas's phosphate powder, or basic slag— . . . . is composed of 15 to 25 per cent. of phosphoric acid and about 45 per cent. of lime. It is not very quick in action, but lasting in effect."

From this description one cannot get much idea of the relative values of these three phosphatic manures, and basic slag suffers by comparison with ground coprolite. Practical experience shows that basic slag has a much higher value than ground coprolite as a manure, and has, moreover, an additional value as a check upon wireworm.

Again, on p. 77, the description of the fungus causing potato disease (phytophthora infestans) is scarcely accurate. In describing the aerial hyphæ which spring from the mycelium in the leaves and push their way through the stomata, the author says:—

"These stem-growths of the fungus produce 'fruit'-spores (DD) in cells (Oogonia), that divide (F) and liberate the active agents in reproduction, tailed zoospores (G) which float in the air, and swim in the moisture, dew, or rain, on potato leaves." The letters in parentheses refer to fig. 18, p. 79. Neither text nor description below fig. 18 is correct. What Mr. Wright calls oogonia are really conidia, and what he calls conidia (F in fig. 18) represent the formation of an oospore from oogonium and antheridium. We must also dissent from the author's views on zoospores floating in the air.

Apart from these defects the primer is well worthy of perusal, and will no doubt meet with success. The practical part is very well done, and this is, of course, the most essential part of the book. WALTER THORP.

*Ornithology in relation to Agriculture and Horticulture.* Edited by John Watson. 220 pp. (London: W. H. Allen, 1893.)

THIS book contains a series of papers by well-known writers. The chief interest will gather around chapters iii. to vii. inclusive, which treat of the common sparrow. The trial of the sparrow is opened very ably by Mr. Chas. Whitehead (for the prosecution). He is well supported in the next chapter by Miss Eleanor A. Ormerod. These two writers for the prosecution will have the support of the vast majority of agriculturists in England, and their arguments contrast favourably with the less practical defence put forward in the two succeeding chapters by the Rev. F. C. Morris and the Rev. Theodore Wood.

Chapter VII. is written by J. H. Gurney, Jun., and from the result of 755 dissections he draws up a table showing that "in England about 75 per cent. of an adult sparrow's food is corn, chiefly barley and wheat, with a fair quan tity of oats." Nobody with experience of grain-growing in England will deny that the sparrow is a terrible pest, and it is time that a movement be made not towards exterminating the troublesome bird, but towards reducing its numbers to normal limits.

Chapter IX. is an interesting defence of the rook, much of which defence this bird merits. It is written by O. V. Aplin, who also contributes a very useful chapter on miscellaneous small birds. WALTER THORP.

## 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.*]

### Vectors *versus* Quaternions.

HAVING a vivid recollection of the pleasure I derived from Prof. Gibbs's attacks upon the quaternionic system in the rather one-sided discussion that took place about two years ago in this journal, I have delayed replying to the letters of Profs. MacAulay and Tait, from an expectation that Prof. Gibbs would have something to say. In this I have not been mistaken; and, as there is a general agreement between us on the whole, I have merely to add some supplementary remarks. Prof. MacAulay refers to me as having raised the question again. I can assure him it has never been dropped. Apart from the one-sided discussion, it has been a live question with Prof. Gibbs and myself since about 1882, and is now more alive than ever. I cannot help thinking that Prof. MacAulay's letter was overhastily written, and feel sure that if he knew as much about the views and methods of those to whom he appeals as he does about Quaternions, he would have written it somewhat differently, or perhaps not have written it at all, from a conviction of the uselessness of his appeal. There is no question of suicide with us; on the contrary, quite the reverse. I am asked whether the "spoonfeeding," as he terms it, of Maxwell, Fitzgerald, &c., is not good enough for me. Why, of course not. It is quaternionic, and that is the real point concerned. Again, he thinks nothing of the inscrutable negativity of the square of a vector in Quaternions; here, again, is the root of the evil. As regards a uniformity of notation amongst antiquaternionists, I dare say that will come in time, but the proposal is premature. We have first to get people to study the matter and think about it. I have developed my system, such as it is, quite independently of Prof. Gibbs. Nevertheless, I would willingly adopt his notation (as I have adopted his dyadical notion of the linear operator) if I found it better. But I do not. I have been particularly careful in my notation to harmonise as closely as possible with ordinary mathematical ideas, processes, and notation; I do not think Gibbs has succeeded so well. But that matters little now; the really important thing is to depose the quaternion from the masterful position it has so long usurped, whereby the diffusion of vector analysis has been so lamentably impeded. I have been, until lately, very tender and merciful towards quaternionic fads, thinking it possible that Prof. Tait might modify his obstructive attitude. But there is seemingly no chance of that. Whether this be so or not, I think it is practically certain that there is no chance whatever for Quaternions as a practical system of mathematics for the use of physicists. How is it possible, when it is so utterly discordant with physical notions, besides being at variance with common mathematics? A vector is not a quaternion; it never was, and never will be, and its square is not negative; the supposed proofs are perfectly rotten at the core. Vector-analysis should have a purely vectorial basis, and the quaternion will then, if wanted at all, merely come in as an occasional auxiliary, as a special kind of operator. It is to Prof. Tait's devotion to his master that we should look for the reason of the little progress made in the last 20 years in spreading vector-analysis.

Now I have, in my turn, an appeal to make to Prof. MacAulay. I have been much interested in his recent R. S. paper. As the heart knoweth its own wickedness, he will not be surprised when I say that I seem to see in his mathematical powers the "promise and potency" of much future valuable work of a hard-headed kind. This being so, I think it a great pity that he should waste his talents on such an anomaly as the quaternionic system of vector analysis. I have examined a good deal of his paper, and can find nothing quaternionic about it except the language concerned in his symbols. On conversion to purely vectorial form, I find that it is greatly improved. I would suggest that he give up the quaternion. If he does not like my notation, or Prof. Gibbs's, or Prof. Macfarlane's, and will invent one for himself, it will receive proper consideration. He will greatly extend the sphere of his usefulness by the conversion. A difficulty in the way is that he has got used to quaternions. I know what it is, as I was in the quaternionic slough myself once. But I made an effort, and recovered myself, and have little doubt that Prof. MacAulay can do the same.

Passing to Prof. Tait's letter, it seems to be very significant. The quaternionic calm and peace have been disturbed. There is confusion in the quaternionic citadel; alarms and excursions, and hurling of stones and pouring of boiling water upon the invading host. What else is the meaning of his letter, and more especially of the concluding paragraph? But the worm may turn; and turn the tables.

It would appear that Prof. Tait, being unable to bring his massive intellect to understand my vectors, or Gibbs's, or Macfarlane's, has delegated to Prof. Knott the task of examining them, apparently just upon the remote chance that there might possibly be something in them that was not utterly despicable. Prof. Knott has examined them, and has made some remarkable discoveries. One of them is that those vector methods in which the quaternion is not the master lead to formulæ of the most prodigious and alarming complexity. He has counted up the number of symbols in certain equations. Admirable critic!

Now, since this discovery, and Prof. Tait's remarks, are calculated to discourage learners, I beg leave to say, distinctly and emphatically, that there is no foundation for the imputation. Prof. Knott seems to have found a mare's nest of the first magnitude; unless, indeed, he is a practical joker, and has been hoaxing his venerated friend. Speaking from a personal knowledge of the quaternionic formulæ of mathematical physics, and of the corresponding formulæ in my notation and in Prof. Gibbs's, I can say definitely that there is very little to choose between them, so far as mere length goes. Perhaps Prof. Knott has been counting the symbols in a Cartesian formula, or in a semi-cartesian one, or some kind of expanded form. I do not write for experts who delight in the most condensed symbolism. I do not even claim to be an expert myself. I have to make my readers, and therefore frequently, of set purpose, give expanded forms rather than the most condensed.

But so far as regards the brief vector formulæ, I find that the advantage is actually in my favour. I attach no importance to this, but state it merely as a fact which upsets Profs. Knott and and Tait's conclusions. It is desirable that I should point out the reason, otherwise the fact may not be believed. In common algebra there is but one kind of product of a pair of quantities, say F and $v$, which is denoted by $Fv$. In vector algebra there are two kinds of products. One of these closely resembles the usual product, whilst the other is widely different, being a vector itself. Accordingly, to harmonise with common algebra, I denote the scalar product by $\mathbf{Fv}$. It degenerates to $Fv$ when the vectors have the same direction. Now, since the quaternionists denote this function by $-\mathrm{S}\mathbf{Fv}$, which is double as long, whilst $\pm \mathbf{Fv}$ becomes $\mp \mathrm{S}\mathbf{Fv}$, it is clear that there must be an appreciable saving of space from this cause alone, because the scalar product is usually the most frequently occurring function.

But there are other causes. The quaternionic ways of specialising formulæ are sometimes both hard to read and lengthy in execution. Look at $\mathrm{S}\,.\,\mathrm{U}\alpha\mathrm{U}\rho\mathrm{S}\,.\,\mathrm{U}\beta\mathrm{U}\rho$, which I see in Tait's book. I denote this by $(\alpha_1\rho_1)\ (\beta_1\rho_1)$, or else by $\alpha_1\rho_1\,.\,\beta_1\rho_1$. Tait is twice as long. But the mere shortness is not important. It is distinctness that should be aimed at, and that is also secured by departing from quaternionic usage. Examples of shortening and clarifying by adopting my notation may be found on nearly every page of Tait's book.

Consider, for example, rotations. Quaternionists, I believe, rather pride themselves upon their power of representing a rotation by means of a quaternion. Thus, $\mathbf{b} = q\mathbf{a}q^{-1}$. The continued product of a quaternion $q$, a vector $\mathbf{a}$, and another quaternion $q^{-1}$, produces a vector $\mathbf{b}$, which is $\mathbf{a}$ turned round a certain axis through a certain angle. It is striking that it should turn out so; but is it not also a very clumsy way of representing a rotation, to have to use two quaternions, one to pull and the other to push, in order to turn round the vector lodged between them? Is it not plainer to say $\mathbf{b} = r\mathbf{a}$, where $r$ is the rotator? Then we shall have $\mathbf{ac} = \mathbf{a}rr'\mathbf{c} = r'\mathbf{a}r'\mathbf{c} = \&c.$, if $r'$ is the reciprocal of $r$. Then Prof. Tait's $\mathrm{V}q\mathbf{a}q^{-1}q\phi\,(q^{-1}\mathbf{b}q)\,q^{-1}$ is represented by $\mathrm{V}r\mathbf{a}r\phi r'\mathbf{b}$. See his treatise, p. 326, 3rd edition, and note how badly the $q\ (\quad)\ q^{-1}$ system works out there and in the neighbouring pages.

What, then, is this rotator? It is simply a linear operator, like $\phi$. It is, however, of a special kind, since its conjugate and its reciprocal are one, thus $rr' = 1$, or $r' = r^{-1}$. Far be it from me to follow Prof. Tait's example (see his letter) and impute to him an "imperfect assimilation" of the linear and vector operator. What I should prefer to suggest is that his admiration for the quaternionic mantle is so extreme that he will wear it in preference to a better-fitting and neater garment. If we like we can express the rotator in terms of a quaternion, in another way than above, though involving direct operations only. But I am here merely illustrating the clumsiness of the quaternionic formulæ in physical investigations, and their unnaturalness, by way of emphasising my denial and disproof of the charge made by Prof. Tait against vectorial methods. The general anti-quaternionic question I have considered elsewhere.

Paignton, Devon, March 24. OLIVER HEAVISIDE.

### Severe Frost at Hongkong.

THE occurrence of severe frost at moderate elevations within the Tropics must be rare. It seems worth while therefore to place on record in the columns of NATURE some portion at least of an official report on the low temperature which (as was stated in NATURE last week) occurred at Hongkong between the 15th and 18th of January:

*Botanic Gardens, Hongkong, February 4, 1893.*

SIR,—The unprecedented cold weather which the region about Hongkong was recently subjected to calls for some notice by this department. Records of experiences of meteorological phenomena such as we have just had besides being of passing interest are so frequently of use in practical dealings with various subjects that for this reason opportunities to record unusual phenomena should not be neglected. It does not, however, come within the province of this department to go much further into the meteorological aspects of the subject than is demanded in connection with its injurious effects on vegetation.

(2) After a period of ordinary Hongkong dry, cool weather rain fell on January 13, and continued daily up to the 16th instant. In the gardens, at 300 feet above sea level, the following quantities of rain were registered with a Glaisher's rain gauge:—

| | |
|---|---|
| January 14 | .14 |
| ,, 15 | .35 |
| ,, 16 | .46 |
| ,, 17 | .45 |

(3) On the 15th instant the temperature fell in the afternoon to 39° F., at 350 feet above sea level. On the 16th, at 9 a.m., it stood at 35°. On the 17th the thermometer stood at 31° at 9 a.m., which was the lowest temperature observed at the Gardens. During this period the sky was overcast except for a short time about noon on the 17th, but on the morning of the 18th it was clear and the sun shone brightly throughout the day, the temperature having risen to 43° at 4 p.m.

(4) Unfortunately there are no official records of temperature at Victoria Peak, 1818 feet above sea level, but, by such information as could be obtained from private observers in the hill district and observations made here, it seems that the temperature must have fallen at the summit to about 25° or 24° F.

(5) On the river at Canton, and between this port and that place, low temperatures were recorded in the reports of the steamships *Powan* and *Honam*. They gave—

January 16 at 1 A.M. 23° about 28 miles below Canton.
,, ,, at 10 A.M. 26° about 25 miles from Hongkong.
,, ,, at 1 P.M. 25° at Canton.
,, 18 at 10 A.M. 28° about 25 miles from Hongkong.

I am indebted to the Office of the Hongkong, Canton, and Macao Steamboat Company for these returns.

(6) On the peninsula of Kowloon the cold appears to have been greater than in Hongkong; ice was seen on pools of water in the roads within fifty feet of sea-level, and at the Kowloon Docks ice was observed at the bottom, thirty feet below sea-level, of an empty dock.

(7) In the harbour the rigging of ships was coated with ice.

(8) Since the records began in 1884 the temperature has not fallen, until now, at the observatory, below 40° F. I remember on one occasion, I think about seventeen years ago, ice was found at Victoria Peak, but there is no record within my experience, which extends back nearly twenty-two years, when ice was observed below 1700 feet altitude.

(9) The continued low temperature combined with fall of rain from an apparently warmer stratum of air above, resulted in the formation of ice varying in quantity from a thin coating on the upper leaves of pine trees growing at 300 feet above sea level, to a thick encasement of perfectly transparent solid ice of 5½ inches in circumference on the blades and bents of grass at the summit of Victoria Peak. The grass bents themselves, which were the foundation on which the ice accumulated, were not more than an eighth of an inch in diameter, yet the formation of ice was so gradual that with the enormous accumulation of ice, which became its own support, the bents retained their natural upright, or but slightly pendent position. These large accumulations of ice were on the windward side of the hill where rain drifted, but even on the lee side the average coating of ice was about 3 inches in circumference.

(10) Evergreen shrubs and trees carried on their leaves solid coverings of ice ⅜ of an inch in thickness. The great weight of this ice caused the branches of trees to assume a pendent form, the strain in many cases causing the limbs to snap off with a crash. All vegetation throughout the hill regions of the Colony was thus covered with ice, as were also most other objects. Telegraph and telephone wires from Victoria Gap upwards were covered with ice ⅜ of an inch in thickness, and, in addition, carried icicles as much as three inches in length as close as they could be packed side by side. This caused many of the telephone wires to break, and the iron post at Victoria Gap which supported them was snapped off a few inches above the ground.

(11) The windward sides of the walls of the look-out house at the Peak were from top to bottom covered with perfectly transparent ice ⅝ of an inch in thickness.

(12) All the hills on the mainland and Lantao island were likewise white with ice, one of the hills (3147 feet) of Lantao having what appeared to be snow for some few hundreds of feet down from its summit. As early as the evening of January 15 the summit of Taimoshan (about 3300 feet) on the mainland had assumed a whitish appearance, presumably from ice or snow.

(13) The effect of the extremely low temperature on vegetation has been disastrous.

(15) The damage in the gardens consist chiefly in the injury or destruction of leaves, but some plants are quite killed, these being natives of much warmer regions than Hongkong. Many of the decorative plants which were not killed will be months before they can regain their ornamental appearance.

(16) Every possible precaution was adopted to minimise the effect of the cold. The plant-houses, which are provided with screens merely to produce shade, were all matted in and the roofs covered with straw. In spite of these precautions, however, many plants suffered very severely. Of ferns in the houses *Polypodium Heracleum* and *Adiantum tetradactylon* suffered most, other kinds being but little affected.

(17) In the orchid-house, which was covered with mats and straw, all our best orchids have suffered very greatly, many being entirely killed while others were so much injured that, even if they survive, it may be some years before they regain their previous luxuriant state. A healthy plant, received from Calcutta several years ago, of *Dendrobium aggregatum*, is apparently killed, while plants of the same species growing by its side, and also others on trees where they had no shelter, which I collected ten years ago on the Lo-fau mountains, about sixty miles from Canton, have escaped unharmed. This seems to show the capability of the plant in adapting itself to colder regions than it is generally found in.

(19) The highest point of the Gardens is 320 feet above sea-level, the lowest part 175 feet. Some plants of the same kinds which were damaged at the upper portions were uninjured at the lower parts of the Gardens.

(20) Of exotic trees planted on the hills *Albizzia Lebbek*, *Aleurites triloba* (candle-nut-tree) and *Eugenia Jambos* (the rose-apple-tree) had all their leaves killed at and upwards of 600 feet above sea-level. Trees of the rose-apple at about 800 feet altitude have been entirely killed.

(21) At 600 feet altitude indigenous plants began to be affected, the injuries increasing with higher altitude until at about 900 feet when the extreme limit of low temperature which some plants could bear was reached, and death ensued. Most of these are tropical plants of which Hongkong, Formosa, the Luchu Islands in the Far East, and Sikkim and Himalaya in India are the northern limits of the geographical area from which they have been recorded. Of the plants killed or injured, *Ficus Harlandi*, Benth., *Gordonia anomala*, Spreng., and *Garcinia oblongifolia*, Champ, are known only from Hongkong. Although many of our indigenous plants have not been yet discovered elsewhere, it is to be expected that when China is better known they will be found over a larger area than the restricted one of this island. The fact of the above named plants having succumbed to the late frost indicates that when they are discovered elsewhere they will be found southward of Hongkong.

(22) Considerable damage to vegetation seems to have been caused about Canton, where the alluvial lands are highly culti-

vated. The Rev. Dr. B. C. Henry, in a letter dated January 26, informs me that "the destruction of vegetation about Canton has been very great. The banana plantations are ruined, and the bamboos have suffered. The *Aleurites triloba* look all shrivelled up, while Begonias, Euphorbias, Crotons and scores of others are simply destroyed." What Dr. Henry reports indicates severer weather at Canton than here, *Aleurites triloba* leaves being shrivelled up at Canton, while they are here at 300 feet altitude uninjured, but at 600 feet they are affected, and completely destroyed a little higher up the hill.

(23) Accompanying this report are six photographic views which were taken on January 16 showing the ice at various places in the Peak district. It is somewhat difficult to represent ice in photographs, as bright light has much the same effect as ice which owes its white appearance merely to reflected light, but it will be understood that the white in these views is produced by ice. CHARLES FORD,

Superintendent Botanical and Afforestation Department.

HON. G. T. M. O'BRIEN. C.M.G.,
Colonial Secretary, &c.

The importance of such facts as these in connection with geographical distribution can hardly be overrated. It is customary to compare the range of a plant with the corresponding mean annual temperature. But it is obvious that the exterminating effect of occasional low temperature must override every other condition. An island is often the last refuge of a species not found elsewhere. Such a frost as occurred in Hongkong would erase the Double Cocoa-nut in all probability from the face of creation, if it occurred in the Seychelles. In any case islands are not easily restocked except with littoral vegetations and the trees distributed by carpophagous birds. It seems evident therefore that the geographical distribution of plants may still be influenced by causes which are catastrophic in their nature. Of this, although not from cold, there is already a striking illustration in the simultaneous destruction of the entire forest vegetation which at one time covered the island of Trinidad in the South Atlantic. Mr. Knight, in the account which he has given in the "Cruise of the Falcon," conjectures that the cause was more probably volcanic than a long drought.

The wave of cold which affected Hongkong (or at any rate the atmospheric conditions which produced it) seems to have been tolerably extended in its range. My friend, Dr. Trimen, writes to me on February 6 from Ceylon:—

"We are having a wonderfully fine and dry time here, with extraordinary cold mornings. Here at Pecadeniya we have been registering at 6 a.m. 53° and 54° F., the lowest ever previously known being a little below 60°. The middle of the day is very hot. Hakgala has been getting frost for the first time on record."

He does not give any dates; but the two exceptional circumstances are sufficiently near together to make it probable that some common cause produced them both.

W. T. THISELTON-DYER.

Royal Gardens, Kew, March 28.

P.S.—Since writing the above I have received from the Colonial Office the accompanying report on the weather of January from the Hongkong Observatory.—[W. T. T.-D.]

The mean temperature was below the average from the 14th to the 24th. The coldest day (air 35°·2, damp bulb 32°·8) was the 16th. The lowest mean temperature of the damp-bulb thermometer occurred on the 17th (air 36°·2, damp bulb 30°·9). Circumstances were anti-cyclonic, with probably abnormally slight decrease of temperature with height. Snow-storms were reported from China to the north and east of the colony. From Macao snow was reported, but that appears to have really consisted of small-sized hail, which fell for four hours. Neither snow nor hail were seen in Hongkong, but the tops of the hills appeared to be covered by snow or hoar-frost. Water exposed in buckets or in pools was several mornings found covered with ice about ¼ inch thick, and a few hundred feet above sea-level both the grass and branches of trees, being cooled below the temperature of the air (which did not fall below freezing-point) owing to evaporation and radiation, were encased in unusually clear and transparent ice without any appearance of crystallisation. As far south as the Straits Settlements the cold was felt, but in a less degree. The temperature appears not to have fallen below 70° in Singapore. At sea strong northerly breezes were observed during the greatest cold. The colony was sheltered by the mainland, and only light northerly breezes were registered till the 20th, when the wind backed to west. It veered to east on the 21st. During the coldest days the pressure was from one to two-tenths of an inch of mercury above the mean. The sky was overcast, but cleared on the evening of the 17th. Owing to radiation the extreme temperatures occurred after this epoch: the lowest air-temperature 32°·0 about 7 a.m. on the 18th, and the lowest damp-bulb temperature 27°·7 about 2.30 a.m. on the same day. W. DOBERCK, Director.

Hongkong Observatory, February 1.

## Mr. Preece on Lightning Protection.

IN the recent Presidential Address to the Institution of Electrical Engineers by Mr. Preece, I find the following reference to myself.

"Prof. Oliver Lodge has . . . endeavoured to modify our views as to the behaviour of lightning discharges, and as to the form of protectors, but without much success. His views have not received general acceptance, for they are contrary to fact and to experience."

I was quite prepared to laugh at this with the rest, but I find that the general and semi-scientific public are apt to take Mr. Preece's little jokes, of which there are many towards the end of this address, as serious and authoritative statements of scientific fact. And it has been represented to me that unless I take some notice of the above, it may be assumed that I wish silently to withdraw from an untenable position without acknowledging having made a mistake.

Indeed, I have already been questioned by a scientific worker as to whether I accepted the above statement as in any sense corresponding to truth.

My reply is that so far was I from that attitude, that I did not suppose that the statement was either meant or would be taken seriously.

The broad question of scientific fact is this:—Given an electrostatic charge at high potential, can the potential be reduced to zero most quietly and safely by a good conductor or by a bad one?

The old lightning-rod doctrine (or drain-pipe theory) said, by an extravagantly good one. I say, by a reasonably bad one. If you employ too good a conductor the mean square of current is appallingly strong, and all manner of dangerous oscillations are set up; whereas in a bad conductor the discharge can be more nearly dead-beat. These oscillations have been experimentally and mathematically demonstrated in a great variety of ways, the unexpected and distinct effects they are able to produce have been displayed, and Messrs. Whittaker have published for me a large book about them.

Some critics have sensibly objected that the book is too big, but I am not aware of any scientific authority who controverts my position.

If Mr. Preece only means that these views regarding lightning and its dangers are not yet practically accepted by the great British Telegraphic Department, that is, I admit, perfectly true.

OLIVER LODGE.

## The Author of the Word "Eudiometer."

FOR some time past I have been endeavouring to find out the originator of the name eudiometer, which is now applied to the measuring tubes used in gas analysis, and possibly the result of the search may be of interest to some of the readers of NATURE.

Naturally my first resort was to text-books and dictionaries, but although the derivation of the word is sometimes given, the name of the author is not stated.

I had great hopes that the third edition of the "Encyclopedia Britannica," published in 1797, would contain the desired information, for the article "Eudiometer" must have been written not long after the invention of the instrument, but it merely calls it "an instrument for observing the purity of the atmospherical air." Descriptions of many forms of eudiometer follow.

The New English Dictionary gives the derivation and the first quotation is "1777. De Magellan (*title*), Glass apparatus for making mineral waters......with the description of some new Eudiometers"; another is "1807. Pepys. *Eudiometer* in *Phil.*

*Trans.* xcvii. 249. Known quantities of the air to be tried, and of nitrous gas being mixed, were admitted......into a graduated tube, which he [Priestley] denominated a eudiometer." This seems to point directly to Priestley as the author of the name as he certainly was the author of the process. (It may be mentioned in passing that, in this paper, Pepys describes the method of calibrating eudiometers, by pouring in equal quantities of mercury from a tube closed at one end and with the mouth ground flat, against which a piece of plate glass is pressed in order to obtain an exact measure of the mercury.)

With these directions I searched in the library of the Royal Society and found Magellan's book; but he uses the name eudiometer as if it were well known. Mr. White, the librarian, very kindly interested himself in the matter and found in Priestley's book, "Observations on different kinds of Air," a statement that he had received from Landriani one of his eudiometers together with a description that he asks Priestley to print, but the latter excuses himself on the ground that it would not be convenient for him to publish the letter at that time. Mr. White found the title of a book by Marsilio Landriani, "Ricerche fisiche intorno alla salubrità dell' aria" (Milano, 1775, 8°). It is not in the libraries of the Royal or of the Chemical Society, and the title does not appear in the catalogue of the library of the Royal Institution, but last week I found the book at the British Museum. On page viii. of the Introduction there is a paragraph of which the following is a translation: "The account of the discovery of nitrous air and of some of its principal properties is briefly set forth, certain defects of Priestley's apparatus are removed, and there is added a detailed description of the *Eudiometer*, for that is the name which I give to my little instrument, from *Eudios*, a Greek word signifying goodness of the air (bontà dell' aria) accompanied by the more useful precautions for its construction." There are some plates at the end of the book containing drawings of the apparatus, and one of them is marked "Eudiometro 1775." This seems to leave it without a doubt that it is to Landriani that we owe the word.

Next as to its exact meaning: by tradition we have been taught that the eudiometer is an apparatus for measuring the goodness of air, and this is obviously what was intended by Landriani. The New English Dictionary derives it from εὔδιος clear (weather) and μέτρον; Roscoe and Schorlemmer derive it from εὐδία, fine weather, and μέτρον; these meanings of the Greek words are no doubt correct, and the name would seem to be more applicable to some kind of weather glass, a signification which the above quotation shows could hardly have been in Landriani's mind. HERBERT MCLEOD.

Cooper's Hill, March 21.

## Blind Animals in Caves.

ALTHOUGH in my previous letter I did not give evidence directly supporting the proposition that blind cave-animals are born or hatched with relatively well-developed eyes, that thesis is a good deal more than a mere supposition, as Prof. Lankester calls it. Nor did I, as Prof. Lankester asserts, proceed to state that no such fact is known or recorded. The condition of the eyes in the newly-born young of the viviparous Amblyopsis, or other cave-fishes, does not appear to have been investigated, although living young were born under observation as long ago as 1844, and exhibited as spirit specimens to the Belfast Society of Natural History. Nor have the early stages of the European Proteus been obtained. But, on the other hand, with respect to cave crustacea, Tellkampf, the original describer of the blind *Cambarus pellucidus* of the mammoth cave, stated that the eyes were larger in the young than in the adult (A. S. Packard, *Amer. Nat.* 1871), and Garman (*Bull. Mus. Comp. Zool.* xvii. 1888-89) states that in very young specimens of *C. setosus*, the blind crayfish of the Missouri caves, "the eyes are more prominent, and appear to lack but the pigment." In another blind subterranean species, *Troglocaris Schmidtii*, occurring in Central Europe, Dr. Gustav Joseph found and demonstrated that the embryo in the egg was provided with eyes. (See Packard, "Cave Fauna of N. America," *Nat. Acad. Sci.* vol. iv. Mem. I.)

Thus, although it is obvious enough that further investigation of the development of cave-animals is required, it cannot be said that it is altogether a "hitherto unattempted embryological research." A discussion of this kind ought not, however, to be a mere logomachia. My purpose is to show that cave-animals afford a particular case of the general problem how to reconcile the law of recapitulation with the theory that adaptations or degenerations are explained by the selection of congenital variations. J. T. CUNNINGHAM.

## The Value of the Mechanical Equivalent of Heat.

IN NATURE for March 16 you published a summary of a communication which I had the honour to make to the Royal Society. My conclusion as to the value of the C.G.S. unit of heat was $4{\cdot}1940 \times 10^7$ ergs (see NATURE, p. 478), and I added the following comment: "If we express Rowland's result in terms of our thermal unit we exceed his value by 1 part in 930, and we exceed the mean value of Joule's (selected) determinations by one part in 350, . . . . if we attach equal value to *all* the results published by Joule his value *exceeds* ours by 1 part in 4280."

I have received so many communications with regard to this last statement, that you will perhaps permit me to answer my correspondents through your columns.

I thought it unnecessary in a short summary to point out that the value (in gravitation and Fahrenheit units) resulting from Joule's own experiments is *not* the usually accepted 772·55. To me it appears an extraordinary thing that 772 is to this day given in the text-books when, so far back as 1880, Rowland conclusively proved that the results obtained from Joule's experiments give a higher value (see Proceedings, American Academy, March 1880).

In 1879 Rowland forwarded to Joule a thermometer by Baudin, which had been directly compared with Rowland's air thermometer. Joule himself then made a careful comparison of his thermometer with the Baudin one, and communicated the results to Rowland. The complete table is given on p. 39 of the paper already referred to. In addition to the correction thus shown to be necessary, further corrections for the capacity for heat of the calorimeter and contents were included, and as the results were published in Joule's lifetime, there can be little doubt but that these corrections received his approval.

I give an example (from p. 44) of Rowland's corrections:—

| | |
|---|---|
| Joule's value (by friction of water, in 1878) ... | 772·7 |
| Correction for thermometer ... ... ... | +3·2 |
| ,, capacity for heat ... ... | + ·2 |
| ,, latitude (Baltimore) ... ... | + ·9 |
| ,, vacuum .. ... ... ... | − ·9 |
| Corrected value at Baltimore ... | 776·1 |

It is evident that Rowland did not claim for his air thermometry an order of accuracy greater than ± ·01°. In the appendix to his paper (p. 197) he remarks that *if* a certain improvement (not then adopted by him) was made, "it is probable that an accuracy of ·01° C. could be obtained from the mean of two or three observations. I believe that my own thermometers scarcely differ much more than that from the absolute scale at any point up to 40° C."

A study of Rowland's methods, and of the tables given in his admirable paper, leads to the conclusion that it is possible that his thermometry is in error by 1 in 1000 over the range 15° to 25°, and such an error would suffice to bring together the results (both in the value of J and in the temperature coefficient of the specific heat of water) obtained by Rowland and myself. The error would, however, but slightly affect the correction of Joule's results.

If we attach arbitrary values to Joule's later experiments, the mean of the corrected values (by Rowland's thermometer) is 776·75 ($g = 32{\cdot}195$); and the mean of all his determinations by various methods is 779·17,[1] and we may regard the above as within 1 in 1000 of the value resulting from Joule's own work on this subject.

I trust that in future our engineers and text-book writers will (even if they ignore the work of later observers) do Joule the justice of discarding the traditional 772, and adopt a value more in harmony with the investigations of that great experimentalist. E. H. GRIFFITHS.

12, Parkside, Cambridge.

[1] In terms of a thermal unit at 15° C.

## THE SENSITIVENESS OF THE EYE TO LIGHT AND COLOUR.[1]

THERE may be some here who have had the pleasure —or the pain—of rising very much betimes in a Swiss centre of mountaineering in order to gain some mountain peak before the sun has had power enough to render the intervening snow-fields soft, or perhaps dangerous. Those who have will recollect what were the sensations they experienced as they sallied out of the comfortable hotel, after endeavouring to swallow down breakfast at 2 a.m., into the darkness outside. Perhaps the night may have been moonless, or the sky slightly overcast, and the sole light which greeted them have been the nervous glimmer of the guides' lanterns. By this feeble light they may have picked their way over the stony path, and between the frequent stumbles over some half hidden piece of rock lying in the short grass they may have had time to look around and above them, and notice that the darkness of the night was alone broken by stars which gave a twinkle through a gap in the clouds, or if the sky were cloudless, every star would be seen to lie on a very slightly illuminated sky of transparent blackness. Although giant mountains may have been immediately in front of them, their outlines would be almost if not quite invisible. As time went on the sky would become a little brighter, and what is termed the *petit jour* would be known to be approaching. The outlines of the mountains beyond would become fairly visible, the tufts of grass and the flowers along the path would still be indistinguishable, and most things would be of a cold grey, absolutely without colour. The guide's red woollen scarf which he bound round his neck and mouth would be black as coal. But a little more light, and then some flowers amongst the grass would appear as a brighter grey, though the grass itself would still appear dark; but that red scarf would still be as black as a funeral garment. The mountains would have no colour. The sky would look leaden, and were it not for the stars above it might be a matter of guesswork whether it were not covered over with cloud.

More light still, and the sky would begin to blush in the part where the sun was going to rise, and the rest would appear as a blue-grey; the blue flowers will now be blue, and the white ones white; the violet or lavender coloured ones will still appear of no particular colour, and the grass will look a green grey, whilst the guide's neckgear will appear a dull brown.

The sun will be near rising, the white peaks beyond will appear tipped with rose; every colour will now be distinguished, though they would still be dull; and, finally, the daylight will come of its usual character, and the cold grey will give place to warmth of hue.

But there may be others who have never experienced this early rising, and prefer the comfort of an ordinary English tramp to that just described; but even then they may have felt something of the kind. In the soft autumn evening, when the sun has set, they may have wandered into the garden and noticed that flowers which in the daytime appear of gorgeous colourings—perhaps a mixture of red and blue—in the gloaming will be very different in aspect. The red flowers will appear dull and black; a red geranium, for instance, in very dull light, being a sable black, whilst the blue flowers will appear whitish-grey, and the brightest pale yellow flowers of the same tint; the grass will be grey, and the green of the trees the same nondescript colour. A similar kind of colouring will also be visible in moonlight when daylight has entirely disappeared, though the sky will have a transparent dark blue look about it, approaching to green. These sensations, or rather lack of sensations of light and colour, which as a rule attract very little attention, as they are common ones, are the subjects of my discourse to-night.

Experiments which can be shown to a large audience on this subject are naturally rather few in number, but I will try and show you one or two.

We are often told that the different stages of heat to which a body can be raised are black, red, yellow, and white heat, but I wish to show you that there is an intermediate stage between black and red heat, viz. a grey heat. An incandescent lamp surrounded by a tissue paper shade, has a current flowing through it, and in this absolutely dark room nothing is seen, for it is black hot. An increase of the current, however, shows the shade of a dim grey, whilst a further increase shows it as illuminated by a red, and then a yellow light. A bunch of flowers placed in the beam of the electric light shows every colour in perfection; the light is gradually dimmed down, and the reds disappear, whilst the blue colours remain and the green leaves become dark. These two experiments show that there is a colour, if grey may be called a colour, with which we have to reckon.

Now the question arises whether we can by any means ascertain at what stage a colour becomes of this grey hue, and at what stage of illumination the impression of mere light also disappears, and whether in any case the two disappear simultaneously.

As all colours in nature are mixed colours, it is at the outset useless to experiment with them in order to arrive at any definite conclusion, hence we are forced—and the forcing in this direction to the experimentalist is a very agreeable process—we are forced to come to the spectrum for information.

The apparatus on this table is one which I have before described in this theatre, and it is needless for me to describe it again. I can only say that it has in all colour investigations been of such service that any attempt on my part to do without it would have been most disadvantageous. The apparatus enables a patch of what is practically pure monochromatic light of any spectrum colour to be placed upon the screen at once, and an equally large patch of white light alongside it, by means of the beam reflected from the first surface of the first prism.

It should be pointed out that this beam of white light reflected from the first prism of the apparatus, having first passed through the collimator, must of necessity diminish with the intensity of the spectrum, when the collimator slit is closed.

Having got these patches, the next step is to so enfeeble the light that their colour and then their visible illumination disappear.

An experiment which well demonstrates loss of colour is made by throwing a feeble white light on one part of the screen, and then in succession patches of red, green, and violet alongside it. The luminosity of the coloured light gradually diminishes till all the colour disappears, the white patch being a comparison for the loss of colour.

If red, green, and violet patches be placed alongside each other, and they are bedimmed in brightness together, it will be noticed that the red disappears first, then the green, and then the violet; or I may take a red and green patch overlapping, which when mixed form orange, and extinguish the colour: the slit allowing red light to fall on the screen may be absolutely closed, and no alteration in the appearance of the patch is found to occur. This shows, I think, that when all colour is gone from a once brilliant colour, a sort of steel-grey remains behind, and that red fails to show any luminosity when the green still retains its colour.

The measurement of the extinction of colour from the different parts of the spectrum was made on these prin-

[1] A Lecture delivered at the Royal Institution of Great Britain by Captain W. de W. Abney, C.B., R.E., D.C.L., F.R.S.

ciples. A box, similar to Fig. 2, was prepared, but having two apertures, one at each side. Through one the coloured ray was reflected, and through the other a white beam of light to a white screen. Both beams were diminished, and when the white and coloured patches appeared the same hue, the amount of illumination was calculated. Fig. 1 shows graphically the reduction of illumination, when the D light of the spectrum is the same intensity as one amyl-acetate lamp at one foot from the screen. To measure the extinction of light, a box was made as in the diagram, closed at each end, but having two apertures as shown, Fig. 2:—E is a tube through which the eye looks at S, which is a black screen with a white spot upon it, and which can be illuminated by light coming through the diaphragm D first falling on a ground glass which closes the aperture, and reflected on to it by M a mirror.

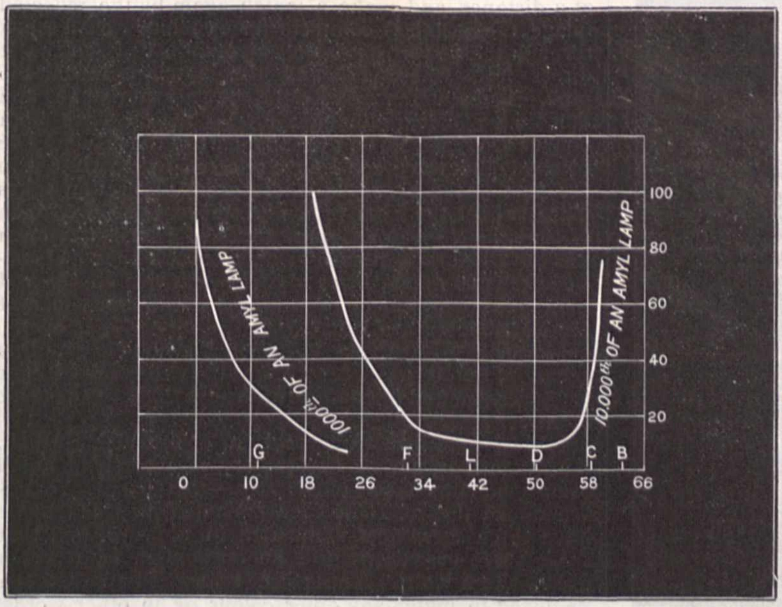



FIG. 1.—Extinction of Spectrum Colours.

The patch of light of any colour being thrown on D, rotating sectors, the apertures of which could be opened and closed at pleasure, were placed in the path of the beam, thus enabling the intensity of the patch to be diminished. D could be made of any desired aperture, and thus the illumination of the ground glass would be diminished at pleasure. After keeping the eye in darkness for some time, the eye was placed at E, when the white spot illuminated by the colour thrown on D was visible, and the sectors closed till the last scintilla of light was extinguished. This was repeated for rays at different parts of the spectrum, and the results are shown in Fig. 3 by the continuous curved lines. The diagram would have been too large had the same scale been adopted throughout for the ordinates; each curve is therefore made on a scale ten times that of its neighbour, counting from the centre.

In the diagram the sodium light of the spectrum before extinction was made of the luminosity of the amyl-acetate lamp (hereafter called AL), which is about ·8 of a standard candle, at 1 foot distance from the source. Before it ceased to cause an impression on the eye, the illumination had to be reduced

to $\frac{350}{10,000,000}$ A L.

| | | | | | |
|---|---|---|---|---|---|
| E light | to | $\frac{65}{10,000,000}$ | | | Of its spectrum luminosity. |
| F light | ,, | $\frac{150}{10,000,000}$ | or | $\frac{15}{1,000,000}$ | |
| G light | ,, | $\frac{3000}{10,000,000}$ | or | $\frac{3}{10,000}$ | |
| C light | ,, | $\frac{11,000}{10,000,000}$ | or | $\frac{11}{10,000}$ | |
| B light | ,, | $\frac{70,000}{10,000,000}$ | or | $\frac{7}{1000}$ | |

There was one objection which might have been offered to this method, and that was to the use of the rotating sectors, and perhaps to the ground glass. This objection was met by first of all reducing the light by means of a double reflection of the beam forming the patch from one or two plain glass mirrors, and also by using a plain glass mirror in the box instead of a silvered glass. By this plan the light falling on the first plain glass mirror was reduced, before it reached the end of the box, 1000 times; and again, by narrowing the slit of the collimator, and also the slit placed in the spectrum, another similar reduction would be effected. All rays thus enfeebled were within the range of extinction. It was found that neither ground glass nor rotating sectors

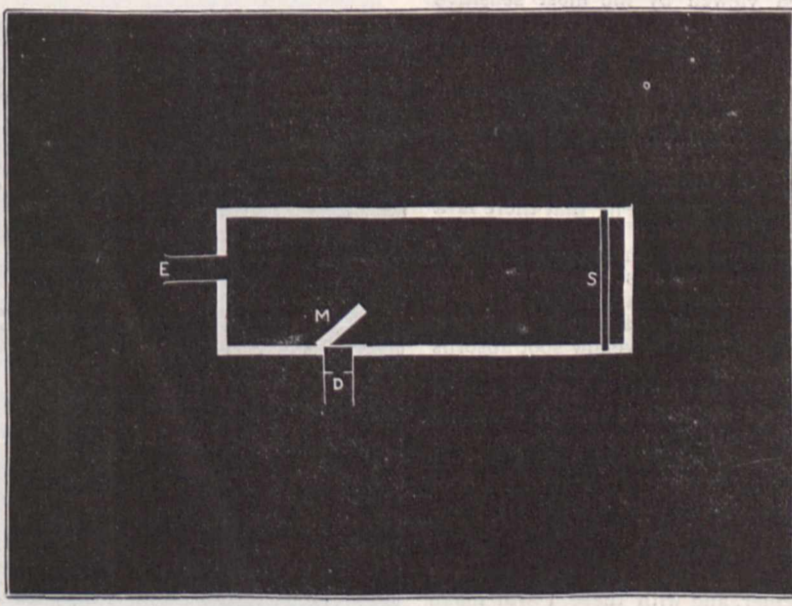



FIG. 2.—Extinction Box.

had any prejudicial effect, and therefore this extinction curve may be taken as correct.

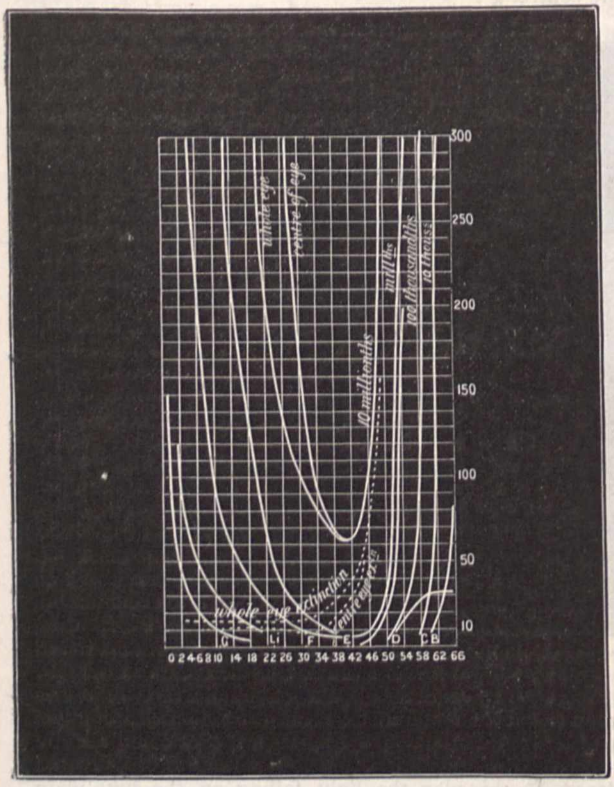



Fig. 3.—Extinction of the Spectrum.

In the curves there are two branches at the violet side, and this requires explanation. One shows the extinction when viewed by the most sensitive part of the eye, wherever that may be, and the other when the central portion of the eye was employed. The explanation of this difference in perception is chiefly as follows :—

In the eye we have a defect—at least we are apt to call it a defect, though no doubt Providence has made it for a purpose—in that there is a yellow spot which occupies some 6° to 8° of the very centre of the retina, and as it is on this central part that we receive any small image, it has a very important bearing on all colour experiments. The yellow spot absorbs the blue-green, blue, and violet rays, and exercises its strongest absorption towards the centre, though probably absent in the very centre, that is, in the "fovea centralis," and is less at the outer edges. That absorption of colour by the yellow spot takes place can be shown you in this way. Any colour in nature can be imitated by mixing a red, a green, and violet together, and with these I will make a match with white and then with brown, two very representative colours, if we may call them colours. Now if I, standing at this lecture table, match a white by mixing these three colours together, using a large patch, the image will fall on a part of the retina of considerably larger area than the yellow spot, and it will appear too green for those at a distance ; but it is correct for myself. If I place a mirror at a distance, and make a match again by the reflected image, the match is complete for us all, as we all see it through the yellow absorbing medium. If I look at it direct from where I stand the match is much too pink. It may be asked why the comparison patches and the mixed colours do not always match since both images are received on the same part of the retina. The reason is that the green I have selected for mixture is in the part of the spectrum where great absorption takes place, whilst the comparison white contains the green of the whole spectrum, some parts of which are much less absorbed than others. I may remark that just outside the yellow spot the eye is less sensitive to the red than is the centre, and this is one additional cause of the difference. See Fig. 5.

More on this subject I have not time to say on this occasion, but it will be seen that the extinction of light for the centre and the outside of the eye differs on account of this.

I must take you to a theory of colour vision which, though it may not be explanatory of everything, at all events explains most phenomena—that is, the Young-Helmholtz theory. The idea embodied in it is that we have three *sensations* stimulated in the eye, and that these three sensations give an impression of a red, a green, and a violet. These three *colours* I have said can be mixed to match any other colour, or, in other words, the three sensations are excited in different degrees, in order to produce the sensation of the intermediate spectrum colours, and those of nature as well.

The diagram Fig. 4 shows the three sensations as derived from colour equations made by Kœnig. It will be seen that there are three complete colour sensations, all of which are present in the normal eye. I would ask you to note that at each end of the spectrum only one sensation is present, viz. at the red end of the spectrum, the red sensation, and at the violet end the violet.

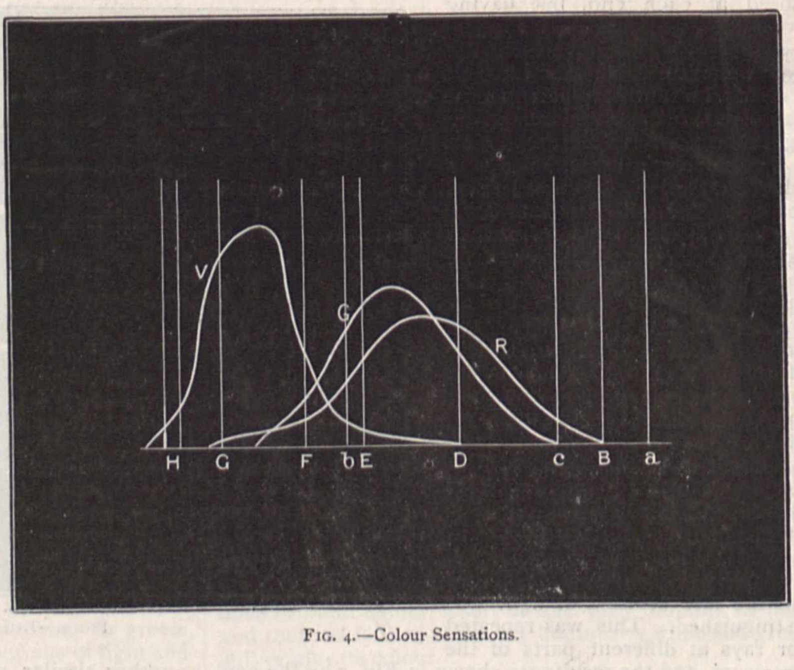



Fig. 4.—Colour Sensations.

This is a matter of some importance, as we shall now see.

It will be recollected that in making the extinctions, the D light of the spectrum was made equal to one amyl-acetate lamp, and the other rays had the relative luminosity to it, which they had in the spectrum before they were extinguished. The luminosity curve of the spectrum is shown in Fig. 5.

Suppose we make all the luminosities of the different rays equal to one A L., we should not get the same extinction value, as shown in the continuous lines in Fig. 3. The violet would have to be much more reduced, but by multiplying the extinction by the luminosity we should get the curve of reduction for equal luminosities, and we get the dotted curves in Fig. 3.

It will be seen that it is the violet under such circumstances that would be the last to be extinguished, and that all the rays at the violet end of the spectrum would be extinguished simultaneously, as would also those at the extreme red. This looks like a confirmation of the Young-Helmholtz theory which I have briefly explained, for we cannot imagine that it can be anything but a single sensation which fails to be excited.

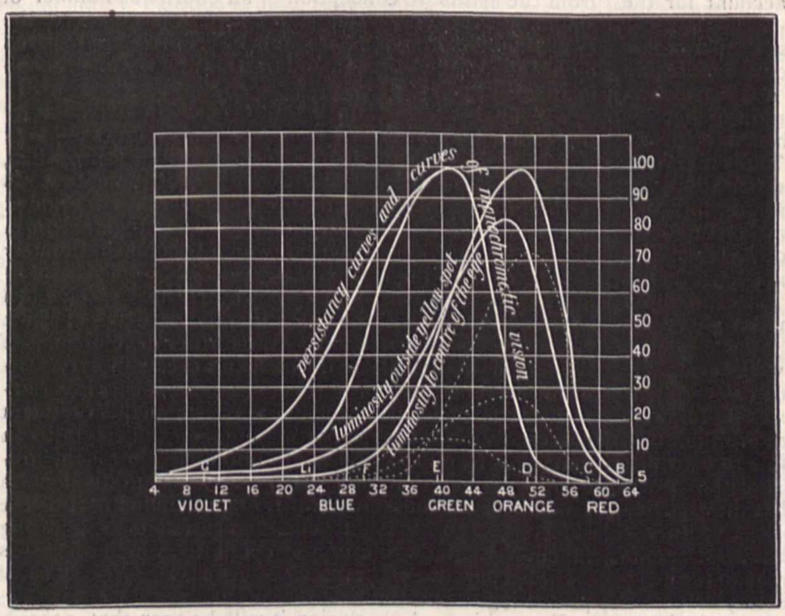



FIG. 5.

The violet is extinguished when it is $\frac{15}{10,000,000}$ A L, that is, a screen placed 817 feet away and illuminated by an A L violet lamp would be invisible. The blue-green (F) light when it is $\frac{17}{10 \text{ millionths}}$ or 770 feet away. The green (E) light $\frac{35}{10 \text{ millionths}}$ or 550 feet away. The orange (D) light is extinguished as before at $\frac{350}{10 \text{ millionths}}$ or 180 feet away, whilst the red (C) light has only to be reduced to $\frac{2200}{10 \text{ millionths}}$ or an A L lamp radiating C light would have to be placed only 67 feet away, whilst the radiation for an A L of the colour of the B light of the spectrum would have to be diminished to but $\frac{2600}{10 \text{ millionths}}$ or the screen would have to be placed 60 feet away.

It is therefore apparent that with equal luminosities the violet requires about 175 times more reduction to extinguish it than does the red, and probably about 25 times more than the green.

This being so, I think it will be pretty apparent that, at all events from the extreme violet to the Fraunhofer line D of the spectrum, the extinction is really the extinction of the violet sensation, a varying amount of which is excited by the different colours. If then we take the reciprocals of the numbers which give extinction of the spectrum, we ought to get the curve of the violet sensation on the Young-Helmholtz theory. For if one violet sensation has to be reduced to a certain degree before it is unperceived, and another has to be reduced to half that amount, it is evident that the violet sensation must be double in one case to what it is in the other; that is, the degrees of stimulation are expressed by the reciprocal of the reduction.

Such a curve is shown in Fig. 5 (in which also are drawn the curves of luminosity of the spectrum when viewed with the centre of the retina and outside the yellow spot). And it will be noticed that it is a mountain which reaches its maximum about E. Remember that the height of the curve signifies the amount of stimulation given to the violet sensatory apparatus by the particular ray indicated in the scale beneath.

Turning once more to Fig. 3, it will be noticed that if any one or two of the three sensations are absent, the persons so affected are, what is called, colour-blind. Thus if the red sensation is absent, they are red-blind; if the green, then green-blind; if the violet, then violet-blind; if both red and green sensations are absent, then the person would see every colour, including white, as violet. The results of the measurement of the luminosity of the spectrum by persons who have this last kind of monochromatic vision should be that they give a curve exactly or at all events very approximately, of the same form as the curve given by the reciprocals of the extinction curve obtained by the normal eye, as the violet sensation is that which is last stimulated.

It has been my good fortune to examine two such persons, and I find that this reasoning is correct, the two coinciding when the curves for the centre of the retina are employed.

Further, I examined a case of violet blindness, and measured the luminosity of the spectrum as apparent to him. Now if the Young-Helmholtz theory be correct, then in his case the violet sensation ought to be absent, and the difference between his luminosity and that of the normal eye ought to give the same curve as that of the violet sensation. This was found to be the case.

Again, the reciprocal of the extinction curves of the red-blind and green-blind ought to be the same as those of the normal eye, for the violet sensation must be present with them also. This was found to be so. We have still one more proof that the last sensation to disappear is the violet.

If we reduce the intensity of the spectrum till the green and red disappear to a normal eye, and measure the luminosity of the spectrum in this condition, we shall find that it also coincides with the persistency curve. On the screen we have a brilliant spectrum, but by closing the slit admitting the light and placing the rotating sectors in the spectrum and nearly closing the apertures, we can reduce it in intensity to any degree we like. The whole spectrum is now of one colour and indistinguishable in hue from a faint white patch thrown above it. If the luminosity of this colourless spectrum be measured we shall get the result stated. The curve obtained in this way is in reality identical with the other curves. By these four methods then we arrive at the conclusion that the last colour to be extinguished is the sensation which when strong gives the sensation of violet, but which when feeble gives a blue-grey sensation.

One final experiment I may show you. It has been remarked that moonlight passing through painted glass windows is colourless on the grey stone floor of a cathedral or church.

We can imitate the painted glass and moonlight. Here is a diaper pattern of different coloured glasses, and by means of the electric light lantern we throw its coloured pattern on the screen. The strength of moonlight being known, we can reduce the intensity of the light of the lamp till it is of the same value. When this is done it will be seen that the pattern remains, but is now colourless, showing that the recorded observations are correct, and I think you are now in a position to account for the disappearance of the colour.

I have now carried you through a series of experiments which are difficult to carry out perfectly before an audience, but at any rate I think you will have seen enough to show you that the first sensation of light is what answers to the violet sensation when it is strong enough to give the sensation of colour. The other sensations seem to be engrafted on this one sensation, but in what manner it is somewhat difficult to imagine. Whether the primitive sensation of light was this and the others evolved, of course we cannot know. It appears probable that even in insect life this violet sensation is predominant, or at all events existent. Insects whose food is to be found in flowers seek it in the gloaming, when they are comparatively safe from attack. Prof. Huxley states that the greater number of wild flowers are certainly not red, but more or less of a blue colour. This means that the insect eye has to distinguish these flowers at dusk from the surrounding leaves, which are then of a dismal grey ; a blue flower would be visible to us whilst a red flower would be as black as night. That the insects single out these flowers seems to show that they participate in the same order of visual sensations. I venture to think, without adopting it in its entirety, that these results at all events give an additional probability as to the general correctness of the Young-Helmholtz theory of colour vision. Where the seat of colour sensation may be is not the point, it is only the question as to what the colour sensations make us feel which the physicist has to deal with. The simpler the theory, the more likely is it to be the true one, and certainly the Young-Helmholtz theory has the advantage over others of simplicity.

## "*THE EPIGLOTTIS.*"[1]

FROM an anthropotomical point of view the epiglottis had for a long time been generally looked upon as a kind of sentinel for the protection of the upper air-passages, when Rückert's comparative anatomical observations showed that the human epiglottis greatly differed from that of mammals, in so far as its relations to the soft palate were entirely altered, and that its physiological conditions *pari passu* had undergone important modifications. The new points of view thus obtained induced Gegenbaur to study the comparative anatomy of the epiglottis and its relations to the larynx, and the present volume is the outcome of his investigations.

The inquiry being undertaken from a morphological point of view the author begins with a study of the different forms of the epiglottis or epiglottoid structures in low classes of animal life. He next discusses the mammalian epiglottis and its relations to the soft palate. The conclusions here arrived at, and which concern the act of deglutition in the lower classes of mammals, lead to a consideration of other organs of the oral cavity, and to an attempt at establishing a connection between these and the apparatus consisting of the epiglottis and soft palate. This in turn induces a minute investigation of the structure of the epiglottis, and of its relationship to the framework of the larynx and the general structure of the respiratory organs in the lowest forms of animal life. In the last chapter the author summarizes the results obtained by his comparative studies and throws out such suggestions concerning the origin, development, and function of the epiglottis as would seem justified by his researches.

Brief as this survey of the course of Gegenbaur's essay necessarily has been, it will be sufficient to show that it is quite impossible to give in the space of a short review a detailed analysis of its contents. Conclusions derived from the synthetic conception of an enormous number of single observations, which extend over a large part of the entire animal kingdom, can only be properly appreciated by a study of the original, and this may be warmly recommended.

The final and most important conclusion arrived at by the author may be briefly summarized as follows :—

Whilst as high up in the scale as in the sauropsidæ, parts of two branchial arches only contribute towards forming the primary hyoid, three more arches are added in the mammals. Two of these growing together form the transition into the thyroid, which becomes intimately connected with the larynx.

The mammalian larynx, however, has received a further addition, viz. the epiglottis, the cartilage of which can only be looked upon as the further development of the fourth branchial arch, which in fishes still serves its primitive function, and in the amphibia appears in a rudimentary form. The exact manner in which this rudiment passes over into the supporting organ of the epiglottis in mammals is, on the whole, still obscure. So much, however, is certain, that the cartilage of the epiglottis is not a product of mucous membrane, but a genuine part of the skeleton, and that it communicates its supporting function to the whole of the epiglottis, which serves as well the purpose of keeping the air-passages open as of protecting the vestibule of the larynx.

From this final conclusion it will be seen that, according to Gegenbaur, the *rôle* of the epiglottis in its highest development is purely a respiratory and protective one.

Pathological observation in man does not admit of these functions of the part being looked upon in any way as indispensable for the existence of the individual. Total loss of the epiglottis has often been observed in various diseases, without the patients either suffering from dyspnœa or from increased liability to the entrance of foreign bodies into the lower air-passages, the *constrictor vestibuli laryngis* (Luschka) in such cases vicariously taking its function. The supposed phonatory *rôle* of the epiglottis, upon which much stress is laid by some eminent singing masters (*e.g.* Stockhausen), inasmuch as they maintain that it influences, according to its more erect or more horizontal position, the "timbre" of the singing voice, is not even mentioned in Gegenbaur's essay. Thus many points connected with this subject still demand elucidation. Still it is impossible to withhold the expression of admiration and of gratitude to the author of the present work for his patient and extensive researches in a very obscure field of comparative anatomy.

[1] "Die Epiglottis," Vergleichend anatomische Studie, by Carl Gegenbaur, with two plates, &c. (Leipzig: Wilh. Engelmann, 1892.)

## NOTES.

ON Saturday the British Eclipse Expedition to West Africa arrived safely at Bathurst. The *Alecto* was there, ready to convey the party up the Salum River to the selected site.

ON Tuesday next, April 11, Mr. J. Macdonell will begin at the Royal Institution a course of three lectures on symbolism in ceremonies, customs, and art; on Thursday, April 13, Prof. Dewar will begin a course of five lectures on the atmosphere; and on Saturday, April 15, Mr. James Swinburne will begin a course of three lectures on some applications of electricity to chemistry. The Friday evening meetings will be resumed on April 14, when Sir William H. Flower will deliver a discourse on seals.

THE Academy of Sciences in Turin announces that the ninth Bressa prize of 10,416 francs, for which all men of science and inventors of all nations are free to compete, is now offered (from January 1, 1891, to December 31, 1894). The prize will be given to whoever, in the judgment of the Academy, shall have, within the period indicated, made the most important and useful discovery, or shall have published the most profound work in the domain of the physical and experimental sciences, natural history, pure and applied mathematics, chemistry, physiology and pathology, geology, history, geography, and statistics. Any one wishing to compete must send his printed work (manuscripts are not accepted) to the President of the Academy. Unsuccessful works are returned, if it be desired.

AT the meeting of the Chemical Section of the Franklin Institute, on February 21, a resolution was passed to the effect that the members had heard with deep regret of the death of their distinguished fellow-member, Dr. F. A. Genth, whose services as an investigator had "added lustre to American science." A committee was appointed to prepare a suitable memoir of Dr. Genth for publication in the proceedings of the Section.

ARRANGEMENTS have been made for another series of summer excursions by the London Geological Field Class. The object of these excursions, which are planned by Prof. H. G. Seeley, F.R.S., is the study of the physical geography and geology of the Thames Basin. The first excursion will take place on April 29, when the students will go from Edenbridge to Westerham by Toys Hill. Each excursion will be under Prof. Seeley's personal direction.

A SCHEME for the organisation of the proposed University for London was adopted at a general meeting of the Association for Promoting a Professorial University for London on March 23, and has been submitted to the University Commissioners. It is printed in the *Times* of April 3.

THE Scottish Technical Education Committee—appointed more than a year ago at a conference held in Edinburgh—has issued a report, from which it seems that Scotland has still a great deal to do before she can be said to possess a satisfactory system of technical instruction. At a recent meeting the Committee passed the following resolution:—"That, in the opinion of the meeting, it is desirable that the whole subject of higher and technical education should be dealt with in a comprehensive measure, and that the opportunity be not lost when the provision for secondary education is being inquired into in all parts of Scotland, to formulate a scheme for organising education beyond the elementary, and reducing in some degree the complications now existing, and the waste resulting from the various authorities that now have a connection with various parts of the educational system of Scotland, and that the chairman (Lord Elgin) be requested to take the necessary steps to bring the subject under the attention of the Government." At the same meeting the future action of the Committee was under consideration. It was felt that in present circumstances it would be very desirable to continue its existence if possible in some more definite shape, and a sub-committee was instructed to inquire under what conditions it might be brought into connection with the National Association for the promotion of secondary and technical education, and, if the sub-committee thought fit, to submit a form of constitution to the next meeting.

SHORTLY after eight o'clock on the morning of April 1 a severe earthquake shock was felt at Catania, and other places at the foot of Mount Etna. It was more especially pronounced at Nicolosi and Zaffarana-Etnea, where the population fled from their houses into the fields.

THE weather continued exceptionally fine over England during the whole of last week, and in Scotland and Ireland the weather was generally fair, although slight rain occurred at times in a few places. The first few days of the period were the warmest experienced as yet this season, and 70° was reached in parts of England. In the suburbs of London the shade thermometer registered 68° or upwards on four consecutive days, and this is the average maximum temperature in June; while on Saturday, April 1, the thermometer reached 71° in the outskirts of the metropolis. The general indications on Saturday were more favourable to a change than for some time past, but the unsettled appearance suddenly gave way to an anticyclone, which reached our islands from the Atlantic, and the conditions again became settled, although the maximum day temperatures during the last few days of the period were generally somewhat lower under the influence of a gentle easterly breeze. The mean temperature for March was several degrees in excess of the average over the whole kingdom, and at Greenwich the excess amounted to 5°; while the mean of all the maximum day readings, which was 57°, was higher than in any previous March during the last half century. The total rainfall for March was also small over the whole country, and at Greenwich the aggregate amount was only 0·38 inches, which is the smallest fall in March since 1854. The *Weekly Weather Report* for the week ending April 1 shows that the duration of sunshine was 85 per cent. in the Channel Islands, 76 per cent. in the south of England, and 72 per cent. in the east of England.

WE recently referred to the unsatisfactory condition of practical meteorology in Spain. The Royal Observatory at Madrid had for many years published results of observations taken at various stations in the peninsula, which furnish valuable materials for climatology; but daily telegraphic reports such as are issued in most other countries were necessary to complete the general synoptic view of weather conditions. We are glad to be able to report that this want has now been supplied. The first daily weather bulletin was recently issued, containing on one side a map showing isobars, wind direction and force, &c.; and on the other the actual telegraphic observations at a number of stations distributed over Spain and south-western Europe. The bulletin is published by the Central Meteorological Institute, which was established some little time since under the direction of Prof. A. Arcimis, to whose persistent efforts we are chiefly indebted for this new contribution to our knowledge of current weather.

THE Meteorological Institutes of Hamburg and Copenhagen have issued their synoptic daily weather charts of the North Atlantic Ocean for the year ending November 1888. These charts contain the best materials for studying the various tracks and positions of the high and low pressure systems over the Atlantic; it is at once seen from them that in different parts of the ocean the storms take different routes, some follow a direct easterly track, others a more northerly course, while some form and others die out in mid-ocean. The great difficulty in storm prediction at present is to determine the routes that storms will take; a serious study of the conditions shown on such charts may eventually lead to the desired end, by enabling us to establish characteristic types of weather which accompany various depressions.

MR. W. H. GREENE and Mr. W. H. Wahl have elaborated a new process for the manufacture of manganese on the commercial scale. A paper by them on the subject was read before a recent meeting of the Chemical Section of the Franklin

Institute, and is printed in the Section's Proceedings for March.

A simple contrivance for determining the refractive index of a liquid without the use of a circular scale or a hollow glass prism, is described in *Wiedemann's Annalen* by Mr. H. Ruoss, of the Stuttgart Technical High School. The liquid is poured into a rectangular vessel, closed on one side by a plane-parallel glass plate. A small plane mirror is half immersed in the liquid, and mounted so that it can be placed exactly parallel to the plane-parallel side. A telescope is directed towards the mirror from outside, about 4 m. distant, its axis being normal to the glass side. To this telescope is attached at right angles a scale 3 m. long. On looking through the telescope the image of the scale in the mirror appears broken into two by the surface of the liquid, the lower image being formed by rays which have undergone refraction and reflection in the liquid. The divisions on the cross-wire measure the tangents of the angles of incidence and refraction respectively, which, since both the sets of rays after reflection are parallel, determine the refractive index of the liquid. A correction has to be applied for the thickness of the plate-glass, and it is best to make the angle of incidence as large as possible. Before taking the readings, the instrument should be adjusted by making the cross-wire coincide with its two reflections in the mirror and the plate, and placing the scale in a parallel and horizontal position with its reflected zero on the cross wire. With these adjustments and corrections the apparatus is capable of giving very accurate results. The angles can be measured to within 5″, and a large number of readings may be taken with different inclinations of the mirror. A set of five measurements for water in sodium light, for instance, gave a refractive index of 1·33276, which coincides with Walther's value to the fourth decimal place, and is subject to a probable error of 0·00003.

At the magnetic observatory of Potsdam some interesting improvements have been made in registration of the needle's variations, a brief account of which is given by Herr Eschenhagen (*Met. Zeits.*). He uses a greater length of abscissæ than usual (20 mm. per hour), and obtains a fine curve by cutting off the border rays by means of a paper screen on the lens, by determining exactly the chemical focus, and by use of a very small mirror. The slit is 0·25 mm. In the case of great magnetic disturbances, trouble sometimes arises from the movable light point going beyond the recording surface, even where, as in Potsdam, this has a width of 190 mm. (7·6 inches), so that the most interesting parts of disturbances may be lost. An attempt was made to remedy this with prisms of a certain angle of refraction, but there are objections to this plan. A more simple and effective method was hit upon; the magnetic mirror is made in three parts, or facets, inclined to each other at an angle of 3°. It is enclosed in a bell-jar, in which the air is kept dry and free from sulphur vapour. The mirror gives three beams, of which usually only the middle one is concentrated in a fine light point on the drum. During a strong disturbance, and just before this light point leaves the drum, another point appears on the opposite side, which takes up and continues the record. These and other improvements will be described in detail ere long in publications of the Observatory.

According to recent researches by M. T. J. van Beneden on the fossil Cetacea found in the regions of the Black Sea, the Caspian, and the Sea of Aral, the basin of the Black Sea contains all those forms which to-day characterise ocean fauna (Balænides, Ziphioides, Delphinides, and Sirenides); and taking also the region of rivers now flowing into that sea into account, it is probable that the whole of Central Europe at the end of the Miocene period was traversed by numerous arms of the sea, the Black Sea reaching to Vienna, Linz, and even to the Lake of Constance. Towards the end of the Pliocene, or the beginning of the quaternary period, owing to considerable depressions, the Straits of the Bosphorus were formed, and the water of the Mediterranean pressed into a basin formerly connected with the Arctic Sea. Thus the passage of a new fauna was made possible, which gradually, under favouring conditions, displaced the older. The Caspian was separated before the new forms had spread so far, and we find in it fifty-four species of fishes, which are neither in the Sea of Aral nor the Black Sea, and only six species which it has in common with those two others.

From recent researches on transference of material in plants (represented, *e.g.* by transference of starch in the potato), Herr Brasse is led to present the following view of what goes on: The assimilation of carbon in the sun's rays is manifested directly in deposition of starch in the chlorophyll grains. Through action of diastase in the leaves, and at a temperature lower than that of its formation, this starch is changed into reducing sugar, which spreads by diffusion from its place of formation into all the tissues of the plant. In certain parts, and especially in the tubers, the sugar is continuously transformed. The tubers, with regard to dissociation, act like the cold wall in vaporisation of a volatile liquid in an enclosed space. The sugar-content of all cells of the plant seeks to enter into equilibrium with that of the cells of the tubers, in which the content is less, because a change of sugar into starch takes place, and the coefficient of this change is here less than that of the converse change in the leaf, the temperature of the tuber being less. Owing to this inequality, there is a transference of starch from the leaf into the tuber, in which it passes through the intermediate stage of sugar. In a similar way Herr Brasse would explain the transference of nitrogenous and mineral plant materials, and their storage in special organs (*Comptes Rendus de la Société de Biologie*).

Mr. E. Lommel has succeeded in fixing photographically the equipotential lines due to a current flowing through a conducting sheet. A current of 20 amperes was sent through sheets of copper 0·5 mm. thick and of various forms. The sheets were covered with sensitive paper strewn with iron filings, which arranged themselves along the lines of magnetic force due to the current, or, what amounts to the same thing, the lines of equal electrical potential along the conductors. The configurations thus obtained were fixed by holding a lighted match for a few seconds above the paper, yielding on development a beautiful representation of the flow through the current sheets. Two of these figures are reproduced in the last number of *Wiedemann's Annalen*. One of them represents the flow through a ring formed by two concentric circles, the current being conveyed by wires soldered to two diametrically opposite points. The other exhibits the equipotential lines in a rectangle with a hole in the middle and wires soldered to two opposite corners. A consideration of the various ways in which the presence of a strong magnetic field affects the configuration of the lines observed has led the author to a possible explanation of the "Hall effect." This phenomenon is only produced by magnetic lines of force running in a direction normal to the plate, or by the normal component of slanting lines. If in a rectangular current sheet made of diamagnetic material two points at equal potential, but on opposite edges of the sheet, be connected with a galvanometer, no current will be indicated until the sheet is brought into a strong magnetic field. According to Weber's theory of diamagnetism, currents are then generated in the molecules opposite in direction to the amperian currents. These molecular currents give rise to a resultant current round the edge of the sheet, strengthening the ordinary current on one side and weakening it on the other. This state of things will be indicated by a deflection of the galvanometer needle and a distortion of the lines of flow, usually designated by "negative rotation." In the case of a paramagnetic body the rotation will be positive.

SEVERAL correspondents have written to us with regard to Mr. Hilderic Friend's letter on "Luminous Earthworms" (NATURE, March 16, p. 463). Several of them record observations which seem to them to confirm his statements. Mr. R. I. Pocock, of the British Museum (Natural History), points out, however, that the property of phosphorescence exists in a highly-developed state in certain terricolous, nocturnal animals, which, although both luminous and vermiform, are certainly neither glowworms, nor yet earthworms. "The power of producing adhesive phosphorescent matter from pores opening upon the ventral surface of the body has," says Mr. Pocock, "been recorded from different quarters of the globe, in the case of several genera of centipedes of the family *Geophilidæ*; and since no special affinity is traceable between all the forms that are known to be sometimes luminous, it is highly probable that the presence of appropriate glands for the secretion of the matter in question is, or has been in the past, characteristic of the whole group. About a dozen species of *Geophilidæ* occur in the south of England. All may be described as worm-like, and some of them are known to be phosphorescent. Curiously enough, the specimens that have been not uncommonly brought to the Natural History Museum as phosphorescent phenomena are referable to a species, *Linotænia crassipes*, which is the most earthworm-like of all, so far, at least, as colour is concerned. An example of this species was, I venture to suggest, the 'luminous earthworm' with the story of which Mr. Friend opens his account of the subject. This centipede is about one or two inches in length; and, although it is impossible quite to acquiesce in the statement that it is 'worm-like in all respects,' nevertheless I think it more than probable that a lady, finding one in the dusk of evening, when it could be but dimly seen, would summarily describe her idea of its appearance by some such expression as that used."

MR. J. E. HARTING, writing in the April number of the *Zoologist*, says that during a recent visit to Greece he lost no opportunity of interrogating the natives as to the birds and beasts to be met with, and was everywhere struck with the ignorance displayed on this subject, and the general indifference which prevailed respecting it. It was not until he reached the great plain of Larissa, where a plague of field voles has been for some time manifest, that he encountered those who could impart some information on at least one small indigenous mammal, namely, that which was causing such mischief and pecuniary loss to the resident land-owners. That it was a vole (*Arvicola*) of some sort was certain; but as to the precise species some difference of opinion had been expressed. Mr. Harting gives much very interesting information as to the animal's habits.

A PAPER on the foundations of the two river piers of the Tower Bridge, by Mr. G. E. W. Cruttwell, was read at the last meeting of the Institution of Civil Engineers before Easter. It was stated that the materials in the two piers, from foundation line up to a level of four feet above Trinity high-water (a height of 60 feet), consisted of 25,220 cubic yards of cement concrete, 22,400 cubic yards of brick-work in cement, and 3340 cubic yards of Cornish granite; making a total of 50,960 cubic yards.

THE Agricultural Research Association for the north-eastern counties of Scotland has issued its report for 1892. A general outline of some of the past year's results is presented, and this is followed by a record of observations, by Mr. Thomas Jamieson, relating especially to grass and clover roots.

MESSRS. E. AND F. N. SPON have issued a convenient little volume of waistcoat-pocket size, containing electrical tables and memoranda, by Prof. Silvanus P. Thompson and Eustace Thomas. The type is small but clear, and there are some illustrations.

MESSRS. CROSBY LOCKWOOD AND SON will publish in a few days a new work by Mr. J. D. Kendall, of Whitehaven, on "The Iron Ores of Great Britain and Ireland," giving an account of our present knowledge of the origin and occurrence of such ores, and the means of reaching and working them. Some of the more important iron ores of Spain are also noticed in the volume.

DR. E. SYMES THOMPSON will deliver lectures on the nose and mouth at Gresham College on April 11, 12, 13, and 14, at six o'clock.

UNTIL comparatively recently bacteriologists have regarded the macroscopic appearances to which organisms give rise when grown on potatoes as affording valuable assistance in distinguishing between otherwise very similar microbes. One notable instance of this is the alleged different behaviour of the typhoid bacillus and the closely allied *B. coli communis* when inoculated respectively on to potatoes. But more recent research has shown that as a diagnostic agent the potato is extremely untrustworthy, and this has moreover been conclusively demonstrated in the case of just these two organisms. Further evidence on this subject has lately been brought forward by Krannhals, "Zur Kenntniss des Wachsthums der Komma bacillen auf Kartoffeln" (*Centralblatt für Bakteriologie*, vol. xiii. p. 33), and the results he has obtained in the case of the cholera organism are very instructive. When cholera declared itself at Riga last August, Krannhals, as Prosector and Bacteriologist at the city infirmary, was deputed to demonstrate officially to the city medical authorities that it really was cholera which had broken out. The culture tests employed exhibited all the typical appearances associated with the cholera organism with the exception of its development on potatoes, upon which it obstinately refused to grow. Suspecting that this might be due to the acidity of the potatoes, slices were prepared and artificially rendered alkaline. On these the bacillus grew abundantly and moreover at from 16°–19° C., whereas it has hitherto been stated to be capable of only developing on this medium at from 30°–40° C. On the acid slices the same negative results were obtained as in all the previous experiments. In consequence of this discovery Krannhals conducted a large number of investigations on the behaviour of the cholera bacillus on acid and alkaline slices of potatoes respectively, and whereas he never failed to obtain vigorous growths on the latter even at the low temperature, he was only in very few instances (4 out of 136 experiments) able to induce its development on non-alkalised slices. But on testing those acid slices on which growths had appeared, it was found that they exhibited a distinct alkaline reaction. This alkalinity, moreover, had nothing to do with the growth of the bacillus, for sterile slices prepared in the same manner were tested both immediately on preparation and after they had been preserved some days, and the same astonishing result was obtained, *i.e.* that the slices of potato originally acid had during keeping become alkaline. Krannhals is led to suggest that in reality the cholera organism is incapable of growing on acid potatoes and that in those cases where it is stated to have developed on such, the medium unknown to the investigator must have, as in his experiments, changed from acid to alkaline. It is important that in future, therefore, the reaction of the potato should be noted both at the time of inoculation and later, when describing the growth of organisms on this medium.

Notes from the Marine Biological Station, Plymouth :—Last week's captures include the rare Nudibranch *Hero formosa*, specimens of the spiny shrimp (*Crangon spinosus*), and of the starfishes *Porania pulvillus* and *Henricia* (*Cribrella*) *sanguinolenta*. In the floating fauna *Plutei*, large and small, have now quite taken the place of the *Auricularia* and *Bipinnaria* larvæ, which were so plentiful a few weeks ago. *Arachnactis* is still obtainable. The unmodified ephyræ of *Aurelia* are now very scarce : most of them are passing through various phases of their metamorphosis into the definitive medusa-form ; and, instead of being plentiful everywhere, are now restricted to special localities.

The additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus sinicus*, ♂) from India, presented by Mr. J. Pitcher ; a Bengalese Cat (*Felis bengalensis*) from Manilla, Philippine Islands, presented by Mr. D. M. Forbes, F.Z.S. ; three Peafowls (*Pavo cristatus*, ♂ ♀ ♀) from India, presented by Mr. T. Guy Paget ; a Leadbeater's Cockatoo (*Cacatua leadbeateri*) from Australia, presented by Mrs. W. Everett Smith ; five Black-headed Gulls (*Larus ridibundus*), a Common Gull (*Larus canus*) European, presented by the Rev. E. M. Mitchell ; three Rhomb-marked Snakes (*Psammophylax rhombeatus*), a Hoary Snake (*Coronella cana*) from South Africa, presented by Messrs. H. M. and C. Beddington ; three Spring-boks (*Gazella euchore*, ♂ ♀ ♀) from South Africa, a Raccoon (*Procyon lotor*) from North America, a Green Monkey (*Cercopithecus callitrichus*) from West Africa, deposited ; two silver-backed Foxes (*Canis chama*), a Cape Bucephalus (*Bucephalus capensis*) from South Africa, purchased ; a Short Death Adder (*Hoplocephalus curtus*) from Australia, received in exchange ; four Great Cyclodus (*Cyclodus gigas*) born in the Gardens.

## *OUR ASTRONOMICAL COLUMN.*

Comet Swift (*a* 1892).—At the Boyden Station, Arequipa, Peru, during the visibility of this comet, all the photographic telescopes were turned towards it, with the result that a fine series of photographs were obtained. In the Bache 8-inch photographic doublet, fifty-six pictures (20 millimetres to the degree) were taken, sixteen of which "are of the first quality" ; in the 2·5-inch photographic doublet (3·8 millimetres to the degree) twelve satisfactory plates were taken, while in the 13-inch refractor and 20-inch reflector several additional negatives were collected. An examination of the negatives, especially of those belonging to the first series, indicated two important facts, as Mr. A. E. Douglass (*Astronomy and Astrophysics* for March) informs us. (1) That the tail of the comet was composed of luminous masses receding from the head at a measurable rate, and (2) that the form of the tail depended largely on some varying force acting at the head. The former of these results was deduced from measurements of the distance of prominent points (8 points were here used) from the nucleus, and the acceleration he obtained amounted to 477,000 miles per day. In discussing the second fundamental results, he deals with the general characteristics of the tail and the special phenomena within half a degree of the head, separately. The tail he describes as "a bundle of slightly divergent straight streamers, branching from each other and joined to the head by one, two, or three well-marked lines." At the southern part of the tail the photographs showed the appearance of a curious twisting effect, while a number of faint streamers, in many cases not joined to the main part of the tail, were also visible. The curve of the natural tangents of the position angles for the date on which they left the head, is, as plotted out by Mr. Douglass, quite irregular, and suggests "non-periodic outbursts from the head of the comet or variations in the repulsive force of the sun" ; where the tail swings to one side there are "large jets in the opposite direction as if the whole resulted from some increase in activity in the head." He suggests that this activity may be connected with solar disturbances, just as magnetic storms on the earth may be connected with certain classes of sunspots.

Paris Observatory in 1892.—From the annual report on the condition of the Paris Observatory during the year 1892, which was presented to the Council in January last by M. Tisserand, the Director, we gather the following brief notes :

Commencing with a short reference to the late Director, l'Amiral Mouchez, and to the great loss both to the Observatory itself and to astronomical science in general, M. Tisserand informs us that, at the suggestion of M. O. Struve, the presidency of the Comité permanent de la Carte du Ciel has passed to the present Director of the Paris Observatory. This choice has been received very favourably, and been confirmed by all the members of the committee. Let us here tender our congratulations to M. Tisserand, who, without doubt, will, in his capacity as president, bring such a grand work as nearly as possible to perfection. In fact, he has commenced by increasing the personnel du Bureau de Mesures des Clichés at the Observatory, and constructing a new machine for the measures, while he hopes soon to publish a fascicule of the *Bulletin de la Carte du Ciel*, which will contain the method of reducing the measures, and of the definite computations of the positions of the stars.

The large equatorial Coudé has this year been subjected to a minute study by M. Lœwy from the point of view of its optical qualities, and of the possibility of improving it still more. The experiments have as yet been restricted to the mounting of the mirror, and it seems that important results may soon be forthcoming. The spectroscopical department, under the direction of M. Deslandres, has, as we are informed, quite assumed a definite form since its foundation in 1890 ; the work done is tabulated under the three headings—sun, stars, and laboratory work. As we have previously referred in these columns to most of the work here accomplished, such as, for instance, the researches of the velocities of stars in the line of sight (250 stars will here be included), photographs of protuberances, faculæ, new hydrogen radiations, &c., further notice will be unnecessary. With the Equatorial de la Tour de l'Ouest, the programme of observations has been the same as in previous years, measures of the positions of comets, nebulæ, and double stars having been obtained. Among the observations here recorded as many as 136 were made of Comet Swift (1892), 41 of Comet Denning (1892), while 250 nebulæ and 120 double stars have been measured. All the above were made by M. Bigourdan. M. Faye also made 77 observations of comets. With the Cercle Méridien du Jardin under the special service of M. Lœwy, the total number of observations amounted to 16,686 ; 453 observations were made of the sun, moon, and planets. M. Paul and Prosper Henry have been occupied in obtaining clichés of the international chart and of the catalogue ; photographs have also been taken of the late nova in Auriga, Jupiter, and Comet Holmes. The Bureau des Mesures des Clichés du Catalogue, under the direction of Mdlle. Klumpke, has been very busy. At this part of the report a brief description of the measuring machine is given, and in a paragraph on "reflexions sur le catalogue et la durée de son exécution," we are told that, if simply the 1200 or 1400 clichés which are demanded for the work in each of the eighteen observations are obtained "on peut espérer d'y atteindre en cinq ou six ans au plus." For measuring the clichés with one machine, and two persons to observe and write the results, 130 clichés could be done in a year, but it would take about 10 years to measure the clichés attributed to one observatory, with one machine and two persons working incessantly. The report contains also all the meteorological work and that done with the minor instruments, concluding with the usual lists of personal publications, observatory publications, changes in the personnel, &c.

The Large Nebula near ξ Persei (N. G. C. 1499).—Dr. F. Scheiner, in *Astronomische Nachrichten* (No. 3157), describes briefly this great nebula near ξ Persei, several photographs of which he has been able to obtain. During November and December last, employing an objective of 4-inch aperture, he took fine photographs, with exposures varying from 1 to 6 hours. The longest exposed plates showed that the size of this nebula has been considerably under-rated, and that it comes nearly up to that of Orion and Andromeda. This nebula, it will be remembered, was discovered by Prof. Barnard with a 6-inch objective, and the position which he gave, 3 h. 54·0 m. R.A. + 36° 1' Decl. (1855·0), referred to the more northern part. Dr. Scheiner's photographs show that its extension southward is very considerable, but, owing to its dimness, was not seen by Prof. Barnard. The form of this nebula, a copy of which is given in this number, is inclined to be spirally, although not so apparent as that of Andromeda, and, curiously enough, it lacks a bright nucleus, as in the latter.

MINOR PLANETS.—The work of discovering minor planets seems, at the present time of the year, to be in a very flourishing condition, although rather restricted to two observers, according to the current number of *Astronomische Nachrichten* (No. 3157). Charlois with 10 and Wolf with 2, bringing the present notation up to 1893 *x*, is a good number for the first quarter of the year, and if this average be kept up we shall soon be driven to indulge in the Greek or German alphabet, or both.

## GEOGRAPHICAL NOTES.

MR. JOHN BARTHOLOMEW, of Edinburgh, whose reputation as one of the foremost British map-makers is world-wide, died on March 30, at the age of 61. His career will be remembered as an epoch in the history of the perfecting and popularising of English maps. Trained in Edinburgh and afterwards under the late Dr. Petermann, in London, Mr. Bartholomew succeeded his father in a cartographical business in Edinburgh, which he steadily enlarged and improved, paying attention not only to excellence of mechanical production, but to the improvements of methods of representation. But the leading characteristic of Mr. Bartholomew's work was his conscientious endeavour to produce the most accurate topographical delineation. The general use of maps coloured orographically in this country is mainly due to the efforts of the Edinburgh Geographical Institute, of which he was the head. Mr. Bartholomew gradually withdrew from active work on account of failing health, and his son, Mr. J. G. Bartholomew, has taken his place in the Geographical Institute.

MR. THEODORE BENT (see p. 519) has been able to reach Aksum, where, however, he only remained for eight days, on account of tribal wars. The party had to retire abruptly because of a threatened fight, in which they were very nearly compelled to take sides, but fortunately the report of an advance of Italian troops to their relief solved the difficulty, and they reached the coast in safety. Despite the shortness of the working time, some good archæological results have been obtained.

THE March number of *Petermann's Mitteilungen* contains a valuable paper on North-west Patagonia by Dr. J. von Siemiradzki, with a map showing the results of his surveys and coloured to bring out the pastoral possibilities of the region. His route in 1891–92 led up the Rio Negro and Rio Limay to Lake Nahuel-Huapi and thence northward through the grassy valleys and bare slopes of the Cordillera to the Upper Biobio valley, whence the expedition passed to the coast of Chile.

THE Royal Geographical Society has given a grant to Dr. H. R. Mill to defray the expenses of a careful bathymetrical survey of some of the larger English lakes. The work, which will be carried out next summer, would be greatly facilitated if use could be had for a few days of a steam launch upon any of the lakes. Windermere, Coniston Water, and Wastwater will probably be sounded in the first place, as they are the most interesting from the limnological point of view.

A PAPER on the Geography and Social Conditions of the Iberian Peninsula read at the March meeting of the Berlin Geographical Society by Prof. Theobald Fischer is published in abstract in the April number of the *Geographical Journal*. The paradoxical character of the peninsula in the variety of its conditions has long been known. The great central plateau with its broken mountain border sloping steeply to the sea throws the bulk of the population towards the coast-line. In the border zone of the peninsula comprising 45 per cent. of its area, more than 66 per cent. of the inhabitants are settled. The only large city in the central plains is Madrid; all the rest of the plateau is occupied by wheat-growers and sheep-rearers; the mining, fruit-growing and industrial interests being all confined to the seaward slopes. There are few parts of Europe in which the physical conditions so plainly dominate the whole character of a country.

## GRAPHICAL SOLUTIONS OF PROBLEMS IN NAVIGATION.

1. IF we suppose the two angles P, S of a spherical triangle SPZ to be together less than two right angles, a plane triangle $S_1P_1Z_1$ may clearly be drawn such that $P_1 = P$ and $S_1 = S$. The sides of the spherical triangle PS, PZ, SZ being respectively denoted by $p$, $c$, $z$, those of the plane triangle may be taken in the following ratios:—

$$P_1S_1 = \tan \tfrac{1}{2}p,$$
$$P_1Z_1 = \tfrac{1}{2} \tan \tfrac{1}{2}(c + z) + \tfrac{1}{2} \tan \tfrac{1}{2}(c - z),$$
$$S_1Z_1 = \tfrac{1}{2} \tan \tfrac{1}{2}(c + z) - \tfrac{1}{2} \tan \tfrac{1}{2}(c - z),$$

These results may be easily verified.

Hence $$S_1Z_1 + P_1Z_1 = \tan \tfrac{1}{2}(c + z),$$

and $$P_1Z_1 - S_1Z_1 = \tan \tfrac{1}{2}(c - z).$$

From these equations we infer that $Z_1$ is the intersection of an ellipse and hyperbola which have the same foci $P_1$ and $S_1$. Suppose now that the line $S_1P_1$ contains, say, 100 divisions, and that a system of ellipses, having $S_1$ and $P_1$ as foci, with major axes 101, 102, 103 . . . and a system of hyperbolas whose axes are 99, 98, 97 . . . are drawn on one side of $S_1P_1$; then, by finding $m_1$, $m_2$ from the equations

$$m_1 = 100 \tan \tfrac{1}{2}(c + z) \cot \tfrac{1}{2}p,$$
$$m_2 = 100 \tan \tfrac{1}{2}(c - z) \cot \tfrac{1}{2}p,$$

we should be able to localise the point $m_1m_2$ as coming between two successive ellipses and also between two consecutive hyperbolas in the diagram.

2. The usefulness of such a diagram lies in its application to problems in navigation. For $p$ may be taken as the north polar distance of the sun, $z$ the complement of his altitude, and $c$ the colatitude of the place of observation. Having determined $m_1$, $m_2$ and thus localised $Z_1$ in the diagram, the angle $Z_1P_1S_1$ is the hour angle which may be suitably measured.

If we interchange $p$ and $c$ in the diagram, thus making $P_1$ and $Z_1$ the foci, the point to be localised is $S_1$ from the equations

$$n_1 = 100 \tan \tfrac{1}{2}(p + z) \cot \tfrac{1}{2}c,$$
$$n_2 = 100 \tan \tfrac{1}{2}(p - z) \cot \tfrac{1}{2}c.$$

The difficulties attending this mode of representation will present themselves in another form in §4. It is sufficient to notice here that this use of the diagram has the advantage of giving two useful angles—$S_1P_1Z_1$, the hour angle, and $S_1Z_1P_1$ the azimuth.

3. The merit of both these modes of representation consists in their being each a single diagram, applicable at any time of year, though in northern latitudes more favourable to accurate measures in summer than in winter. Their demerit consists in the preliminary calculations of $m_1$, $m_2$, or $n_1$, $n_2$. This, however, might be minimised by supplying, along with the diagram, tables of the values of $m$ for two arguments $\theta$ and $\phi$ given by

$$m = 100 \tan \tfrac{1}{2}\theta \cot \tfrac{1}{2}\phi$$

The whole amount of preliminary calculation would then consist in adding and subtracting $p$ and $z$, and looking out $m_1$ and $m_2$.

I shall now investigate the nature of a diagram which requires no preliminary calculation.

Returning to the spherical figure SPZ, let us suppose SP to be fixed while the sides PZ, SZ vary so that Z describes a curve on the sphere. The corresponding point $Z_1$ will describe a corresponding locus on the plane. For example, if L describes a small circle with P as centre, the locus of $Z_1$ will be given by

$$\tan c = \tan\{\tfrac{1}{2}(c + z) + \tfrac{1}{2}(c - z)\}$$
$$= \frac{P_1Z_1}{1 - P_1Z_1^2 + S_1Z_1^2}.$$

Now, if we draw a perpendicular $Z_1N$ to the side $P_1S_1$ we shall have

$$P_1S_1^2 - S_1Z_1^2 = P_1N^2 - S_1N^2$$
$$= \tan \tfrac{1}{2}p(2P_1N - \tan \tfrac{1}{2}p);$$
$$\therefore\ P_1Z_1 = \tan c \tan \tfrac{1}{2}p(\operatorname{cosec} p - P_1N).$$

This shows that the curve described by $Z_1$ is a conic section of eccentricity $\tan c \tan \tfrac{1}{2}p$, with focus at $P_1$ and directrix perpendicular to $P_1C_1$ at a distance cosec $p$ from $P_1$.

Similarly, the curves corresponding to small circles about $S_1$ are conics with a common directrix and with focus at $S_1$, their curvatures being turned the opposite way from those about $P_1$.

The lines whose focus is $P_1$ are curves of equal latitude, and those whose focus is $S_1$ are Sumner lines. Suppose systems of both kinds of lines to be drawn, the figure will be divided into small quadrilaterals, and the eye, aided by a scale with small divisions, would approximately determine the point within any quadrilateral at which the values of $c$ and $z$ are given, intermediate between those of the bounding sides. It is difficult to estimate the error to which this determination would be liable, but supposing the linear dimensions of a quadrilateral at a distance of 10 inches from $P_1$ were comparable with the tenth of an inch and that an error of one-hundreth of an inch were committed in the direction ⊥r to $P_1Z_1$, this would mean an error of 3 or 4 minutes in the measured value of the hour angle. This error would be important, but not large enough to condemn the method, and the estimate shows that the scale of the diagram should be as large as is practicable.

If we confine the diagram to points in north latitudes $c$ may be taken to range between 30° and 90°, though it would obviously be desirable also to draw a few lines for which $c$ is $>90°$. The range of $z$ may be taken between 10° and 80°. The distance between the foci is, as we have seen, $\tan \frac{1}{2} p$ and the distance between the directrices is readily proved to be $\cot \frac{1}{2} p$. The consideration which determines the scale on which the curves should be drawn is that the Sumner for which $z = 80°$ should appear in the diagram as far as it may be required.

The curves in each diagram are different from those in every other for different values of $p$; for although it might at first appear that since the distance from the focus to the directrix is the same for $180° - p$ as it is for $p$ some saving would be effected, the indications of the same curves in the two cases are different, and the Sumners are placed differently in regard to the parallels of latitude. In the case of the sun a diagram for every ten minutes change in declination would probably be necessary, and this would mean an enormous amount of work. Diagrams for a few of the best stars could, however, be constructed on this principle and would be extremely useful.

It will have been noticed that the angle $Z_1S_1P_1$ is equal to the angle ZSP in the spherical figure, but the azimuth is not represented in the plane figure. The following properties of the plane curves may therefore be stated:—

(1) The angle at which $S_1Z_1$ cuts the sumner at $Z_1$ is equal to the angle at which $P_1Z_1$ cuts the parallel of latitude.

(2) If a tangent at $Z_1$ be drawn to either curve, say the sumner, to cut $S_1P_1$ in T and perpendiculars be drawn from T to $Z_1P_1$, $Z_1S_1$ meeting them in M and N, then

$$\cos(\text{azimuth}) = \mp \frac{TM}{TN}$$

according as T falls between $S_1$ and $P_1$ or not. From this result a graphical determination of the azimuth is easily obtained.

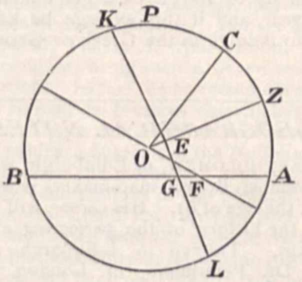
4. If we take $Z_1P_1$ for base line the curves to be drawn are curves of altitude and polar distance. This method of representation is tempting as the angles at $P_1$ and $Z_1$ are then the hour angle and azimuth. Moreover it would be a very convenient way of producing the diagrams to arrange them for consecutive values of the colatitude. Unfortunately there are serious objections. Suppose the common directrix of the polar distance lines cuts $P_1Z_1$ produced in X, then when the sun is in the southern hemisphere these lines are hyperbolas on the remote side of the directrix from $P_1$ and they diverge rapidly for consecutive values of $p > 90°$; so much so that, when the colatitude is between 30° and 40°, it is impossible to represent them on a scale which would be of any value. For places in the tropics there would not be the same objection, and diagrams drawn on this principle would be convenient in those regions.

There is another difficulty. In winter, in northern latitudes, the azimuth and hour angle may be together greater than two right angles or, what is equivalent, $p + z$ may be $>180°$. In that case the construction we are going upon fails, although it is possible to meet the difficulty.

The point is interesting, and admits of the following explanation:—In the figure P is the north pole, Z the place of observation, AB the diurnal path of the sun. If C be the middle point of PZ, then all points above the plane through the centre O perpendicular to OC may appear in the plane diagram supposed large enough. Again a plane KL perpendicular to OZ corresponding to $z = 80°$ limits the area in which observations may be taken. If, therefore, the sun were observed between F and G he would be out of the diagram, and this means that $p + z > 180°$.

The difficulty may be overcome by solving graphically another triangle $S_1{}^1P_1Z_1$ corresponding to $S^1PZ$ in the spherical figure where $S^1$ is diametrically opposite to S. For, if $SZP + SPZ > 180°$ then $S^1PZ + S^1PZ < 180°$. Hence, if we interchange $Z_1$ and $P_1$ in the diagram and pick out the intersection of the curves $180° - z$ and $180° - p$ we shall thereby find graphically the supplements of the hour angle and azimuth.

5. To these modes of representation may be added stereographic projection on the plane of the equator which admits of lines of equal latitude and Sumner lines being represented by




systems of circles and of two angles of the spherical triangle being represented in the corresponding plane figure.

6. The object of all such methods is to facilitate the drawing of lines of position on a Mercator's chart, and as the hour angle must be determined with the greatest possible precision, the diagram should be on a large scale with hour angle lines drawn upon it at suitable intervals.

With this in mind the most practical of the foregoing methods would seem to be the first, viz. that in which there is a single diagram, cut into sections, not necessarily on the same scale, but large enough to admit of the hour angle lines and perhaps also azimuth lines being drawn upon it.

## *ANTHROPOLOGICAL USES OF THE CAMERA.*

AN interesting paper on the anthropological uses of the camera was lately read by Mr. E. F. im Thurn before the Anthropological Institute of Great Britain and Ireland, and is now reprinted in the Institute's "Journal."

Mr. im Thurn points out that primitive phases of life are fast fading from the world in this age of restless travel and exploration, and urges that it should be recognised as almost the duty of educated travellers in the less known parts of the world to put on permanent record, before it is too late, such of these phases as they may observe. It is certainly, however, he says, not a sufficiently recognised fact that such records, usually made in writing, might be infinitely helped out by the camera.

As illustrating the small use of the camera for this special purpose, Mr. im Thurn calls attention to the almost universal badness of illustrations of living primitive folk in books of anthropology and travel, when these illustrations are not merely what may be called physiological pictures. Of old the book illustrator, if, as was usual, he was not himself the traveller, drew as pictures of primitive folk, merely the men and women that surrounded him, drew figures of men and women of his own stage of civilisation, and merely added to these such salient features as he was able, from the traveller's tales, to fancy that his supposed primitive subjects had. So in 1599 the imaginative artist of Nuremberg who drew the pictures for the rare Latin abbreviation of Sir Walter Raleigh's "Discoverie of Guiana" gave to the world his impressions of the "Amazons," the "Headless Men," and the "Men who dwelt on trees" which are typical of the pictures of "savages" which adorn the travellers' books up to nearly the present century.

Mr. im Thurn refers also to the beautifully executed illustrations by Bartolozzi in Stedman's "Dutch Guiana," in which, in place of natives, are shown, with the necessary change of dress, simply Europeans of more than average beauty of form. There were doubtless exceptions to the misrepresentation of primitive folk, and the greatest of these exceptions known to Mr. im Thurn is the beautiful series of drawings by Catlin of North American Redmen. But Catlin enjoyed the unusual advantage not only of considerable technical skill as an artist, but of living among the folk whom he drew and about whom he wrote. Even his drawings, valuable as they are, and artistically superior as they are, are far from having the value of the accuracy of photographs.

The modern anthropological illustrator does indeed generally draw from photographs; but almost always from photographs taken under non-natural conditions. Mr. im Thurn mentions as an example a picture of the Caribs of his own country of Guiana, which appears in one of the most valuable and accurate of recent anthropological books. This picture was the best attainable, and is evidently taken from a photograph; yet it gives no hint of what Caribs are like in their natural state. The explanation is easy. During Mr. im Thurn's many years' acquaintance with these Caribs, both in their native wilds and during their brief visits to the town, he has often been struck by the marvellous difference in their appearance when seen under these two differing conditions. It is true that in his natural surroundings the Carib is but very lightly clad, whereas, on the rare occasions when he enters the town he sometimes, but by no means always, puts on a fragmentary and incongruous piece or two of the cast-off clothing of white men, intending, by no means successfully, to adorn his person; but such separable accidents of rags by no means explain the full change in his appearance. Mr. im Thurn has seen the same men, in their distant homes on the mountainous savannahs between Guiana and the Brazils, though clothed with but a single strip of cloth, two or three inches wide and perhaps a yard in length, and either unadorned or adorned with but a scrap of red or white paint, look like what the novelists describe as well-groomed gentlemen. Yet the same individuals in Georgetown, without any added clothing or adornment, look the meanest and wretchedest folk imaginable. The sense of shyness and mean cringing fear which in the town doubtless drives out from them their innate sense of freedom and happy audacity, seems to find outward expression and completely to alter their bodily form. And it was quite evidently under some such depressing circumstances as these that the Redmen—who, by the way, were probably Ackawois and not "True Caribs"—who are shown in the illustration referred to, were photographed.

Just as the purely physiological photographs of the anthropometrists are merely pictures of lifeless bodies, so the ordinary photographs of uncharacteristically miserable natives seem to Mr. im Thurn to be comparable to the photographs which one occasionally sees of badly stuffed and distorted birds and animals.

Mr. im Thurn gives a clear and most attractive account of his own photographs of phases of primitive life in Guiana—photographs which, at the time of the reading of his paper, were shown on the screen. The following are some extracts from this part of the paper:—

Fifteen years ago I went out to Guiana as curator of the public museum, and in that capacity travelled much in the interior of that colony, only the seaboard of which was, and very little more now is, inhabited. Ten years ago I entered the service of the Government, and, as magistrate, took charge of a large district inhabited almost solely by Redmen. And I remained under those circumstances until, about two years ago, I was transferred to a neighbouring and still larger district of which it may be said that up to the time of my going there the white men who had visited it might be counted on the fingers of one hand. Throughout this time I have lived really among these pleasant red-skinned folk, now and again, for periods of greater or less duration, living not only among, but as they do; and throughout that period I have had none but Redmen as my servant friends. They have got used to me, and I have got used to them, and doubtless in this respect I have enjoyed greater advantages in the matter of gaining their confidence than the ordinary traveller, who merely passes through a country, could hope to enjoy. Some ten years ago, in a book on the "Indians of Guiana," I told all that I then knew about them. Though of course further experience has now taught me a good deal more about them, I must not here linger on anything that does not touch my special subject of to-night—my experiences as a photographer among them.

That to gain the confidence of uncivilised folk whom you wish to photograph is one of quite the most essential matters you will easily understand. The first time I tried to photograph a Redman was among the mangrove trees at the mouth of the Barima River. My red-skinned subject was carefully posed high up on a mangrove root. He sat quite still while I focussed and drew the shutter. Then, as I took off the cap, with a moan he fell backward off his perch on to the soft sand below him. Nor could he by any means be persuaded to prepare himself once more to face the unknown terrors of the camera. A very common thing to happen, and to foil the efforts of the photographer at the very moment when he has but to withdraw and to replace the cap, is for the timid subject suddenly to put up his hand to conceal his face, a proceeding most annoying to the photographer, but interesting to the anthropologist, as illustrating the very widespread dread of primitive folk of having their features put on paper, and being thus submitted spiritually to the power of any one possessing the picture.

With reference to my earlier remarks on the difficulty of discerning in the ordinary illustrations the real bodily appearance of uncivilised folk, photographs of the True Caribs of Guiana will be shown on the screen. And in so doing it may, without entering into elaborate detail, be once more pointed out that the red-skinned inhabitants of Guiana are distinguishable into three groups or branches (see "Among Indians of Guiana," p. 159, and "Proceedings of Royal Geographical Society," October, 1892). Though the actual pre-European history of these three is, unfortunately, still greatly a matter of conjecture, it is convenient to use such conjectures as seem most reasonable on this subject as a means of distinguishing the branches—that is to say, it is well to bear in mind that probably of the tribes at present in Guiana the Warraus, who inhabit the swamps about the mouth of the Orinoco, were the earliest occupiers, but that there is at present no evidence at all to show whence these people reached their present homes; that another of the branches, represented only by the Arawacks, who inhabit the whole sea-coast of that country with the exception of the more swampy lands of the Warraus, probably reached their present homes from the West Indian Islands long after the Warraus were already established in those parts; and that the third branch, usually called the Carib branch, and represented by the Ackawois, Macusis, Arecunas, and by the "True Caribs," came also from the Islands, but at various times, and made their way, in somewhat various directions, into the back lands of the country. The first set of pictures I am about to show you all are of this last or "True Carib" branch.

The first is of a middle-aged man who lives in the first falls of the Barima River. A single glance at it and a comparison of it with the ordinary, even the best book illustrations of Caribs, will at once serve to make plain the advantage of the photographic method used among the people in their own homes over any other method of showing what these primitive folk are really like. Before shooting the falls in their canoes the Redmen always carefully examine the state of the river to see which rocks are exposed, which lurk as hidden dangers beneath the surface in that particular state of the water; and it was while he was engaged in this cautious survey that this photograph of this Carib was taken. The next is of the same man taken under somewhat different circumstances. The hospitality of these persons is almost unbounded, and the etiquette of its observance is rigidly fixed. The master of the house, when expecting guests, grooms himself carefully and puts on his best dress and ornaments, these often, as in this case, consisting only of a narrow waistcloth by way of dress and of a necklace and armlets of white beads by way of ornament. Thus honouring the occasion to the best of his ability, he sits, somewhat stolidly, outside his house awaiting his guests, with whom, when they arrive, he will, without rising or in any other way testifying any interest, exchange one or two entirely conventional and monosyllabic sentences, dropping them out one by one at long intervals.

It is generally supposed that these red-skinned folk are undemonstrative in their bearing towards one another. But this really is only in the presence of strangers. When alone, or before others with whom they are familiar, their bearing toward each other is even caressing. Such a picture as this, of three Caribs standing with their arms round each other's necks, may often be seen.

The next picture, of a young Carib man, perhaps a little above the average in physique, is intended to show that these people, though not tall, are a fine people in the point of physical and muscular development.

Again, in the matter of facial expression, the ordinary conception of these people as dull and expressionless should give place to the truer idea that, when not made shy by the presence of unaccustomed strangers, there is a great deal of life and even in some cases of beauty in their appearance. It is practically impossible for a stranger to see them in this their more pleasing and natural state, except when, as I now do in this picture of three Carib lads, they are taken under the most natural conditions, and distance and time being for the purpose annihilated, they are shown you in the most natural conditions but without their knowledge.

That it may not be said that in my anxiety to impress you with my own too favourable ideas of these red-skinned friends of mine, I have elected only to show you young fellows in their too brief prime, I next show you an old Carib. I must, however, admit that he is only old for a Redman. His age was probably about forty-five. But these happy childlike people lead but a short if a happy life, and are old at fifty, and rarely survive to sixty. . .

Another obvious, but insufficiently used, use of the camera for anthropological purposes would be for the better illustration of collections of objects of ethnological interest. Those who have tried know best the difficulty of showing these in an effective and interesting manner. Comparatively elaborate and correspondingly artistic objects made and used by a people who have made considerable progress without attaining what we are pleased to call civilisation, are easily shown in an attractive manner; but the simpler objects, illustrating the daily life of people in a much more primitive state of civilisation, are not so easily placed. The articles which constitute the dress and ornaments of a people which makes but little use of ornament and less of dress, are generally of so simple a nature that when stored in rows or, as I am afraid is sometimes the case, in heaps or even in bundles, in museum cases, they too often seem deficient in interest to the very curators of the museum, and are naturally much more so to the outside public. Yet these same things, very likely, to one who has seen them in actual use, seem, just because of their simplicity, more interesting than the elaborate dancing masks and such like. It has been suggested —possibly the suggestion has been carried into effect—to display these on lay figures; but when it is remembered how very few of these simple articles of dress or ornament are worn at any one time, it is obvious that for their proper display in the suggested manner the number of lay figures which would be required would, for reasons both of economy and of space, make the plan ineffective. A much more feasible plan would be to place by the side of each object, or group of objects displayed, a photograph of the object—preferably of the identical object. A few examples will better explain what I mean :—

The first is a photograph of a Partamona (Ackawoi) Redman in a curious dress made and worn for a special festival celebrated by those people and called Parasheera. The dress consists of three parts, which may be described as skirt, cloak, and mask, all made of the bright greenish-yellow, immature leaves of the Æta palm (*Mauritia flexuosa*). Probably there is not an example of this dress in any existing museum; for it is probable that no white man except myself has ever seen it, and I frankly confess that I was deterred, as has often been the case under similar circumstances, from bringing away an example of the dress by the consideration that when seen off the body of the wearer it would look like nothing in the world but a small bundle of withered palm leaves, and would to the uninitiated seem supremely uninteresting.

The next example I show you is a picture of a Macusi lad in full dancing dress. Those who are acquainted with the ordinary heaped curiosities of the average ethnological collection will perhaps recognise the typical head-dress of bright parrot and macaw feathers, the loose hanging ruff of alternate black curassow and white egret feathers, and the strip of waist-cloth upheld by a cotton belt, which constitutes the whole of this dress; and such persons will probably recognise that these articles seen, as in this photograph, *in situ*, acquire a new interest.

Again, one of the commonest articles from Guiana seen in museums is the necklace of peccary teeth, much affected by all the Carib tribes. But in now showing you one of the finest specimens of this ornament I have ever seen, it will probably gain very much in interest from the fact that I am able at the same time to throw on to the screen a picture of the actual necklace on the Macusi, named Lonk, from whose shoulders I acquired it. And it may in passing be of interest to add that these necklaces, in the manufacture of which only the tusk teeth of the peccary are used, so that in proportion to its size each represents a very large number of animals, are most highly valued as heirlooms, and as representing the accumulated prowess not only of the wearer for the time being, but also of his ancestors, for this property is handed down in the male line of descent, and is added to by each holder. . . .

In short, a good series of photographs showing each of the possessions of a primitive folk, and its use, would be far more instructive and far more interesting than any collection of the articles themselves. Or, if it is desired to illustrate not the possessions but the habits of such folk, the thing can be done in the same way. A few examples from a large series showing the games of these people will illustrate this.

Many of their games are dramatic representations of ordinary incidents in their work-a-day life. One represents their rare and eventful visits to the distant town. Of the many figures in this game one represents the fully-manned canoe in which they go on their journey down the big rivers of the country. All but two of the players, seated on the ground, the one behind the other, and each clasping the player in front of him, form a long line, which, by the action of the feet and thighs of its constituent members, drags itself slowly forward, the whole swaying from side to side. In this way—which must certainly involve a considerable amount of somewhat painful friction, considering the hardness of the stony ground traversed and the unprotectedness of the skins of the players—a very realistic representation of the forward rolling motion of a large and well-manned canoe, such as would be used on a real journey, is attained. And the illusion is assisted by the players' noisy imitation of the regular and most characteristic rhythmic beat of the paddles against the sides of the canoe, and of the shouts of the paddlers.

After several other figures, another comes, in which the players, all standing in line, each falls forward on his hands and feet, his thighs the highest part of him, so that the whole line of players, with their closely pressed bodies, forms a long tunnel, through which each player in turn has, as in a well-known figure in the old-fashioned dance of Sir Roger de Coverley, to pass, but by creeping. The journey, that is, is nearly over; and the home-comers, leaving the broad river up which they have come so far, have turned into the narrow creek or side stream densely roofed with low hanging trees, which leads directly to their homes; and under this natural tunnel the canoe has to force its way.

Other games to be seen among the Redmen of the borders of Guiana and Brazil are simple representations of the doings of animals. For instance, one represents an aguti in a pen and the attempts of a jaguar to get him out. The players form a ring, their arms round each other's necks. Inside this circle one of the players crouches, and represents an aguti—a small animal often kept in captivity by the Redmen—inside the pen. Outside the pen another player watches; it is the jaguar looking with hungry eyes on the aguti. He tries to get the aguti out between the bars of the pen, that is, between the legs of the ring of players. But the living pen whirls round and round, and it is no easy task for the jaguar to seize the aguti and drag it out.

Yet more curious is the whipping game of the Arawacks. It is played by any number of persons, but generally only by men and boys, for one, two, or three days and nights—as long, that is, as the supply of *paiwari*, the native beer, holds out. The players, with but brief intervals, range themselves in two lines opposite each other. Every now and then a pair of players, one from each line, separate from the rest. One of these puts forward his leg and stands firm; the other carefully measures the most effective distance with a powerful and special whip with which each player is provided, and then lashes with all his force the calf of the other. The crack is like a pistol shot, and the result is a gash across the skin of the patient's calf. Sometimes a second similar blow is given and borne. Then the position of the pair of players is reversed, and the flogged man flogs the other. Then the pair retire, drink good-temperedly together, and rejoin the line, to let another pair take their turn of activity, but presently, and again and again at intervals, to repeat their own activity.

It has been said that the most active players of this extraordinary game are the men and boys. But occasionally the women take a part also. And it is noteworthy that when this is the case a wooden figure of a bird, a heron, is substituted for each of the whips, and a gentle peck with this bird is substituted for the far more serious lash of the whip. I do not know that any equivalent example of the fact that the germ of the idea of courtesy to the weaker sex exists among people even in this stage of civilisation is on record.

## SOCIETIES AND ACADEMIES.

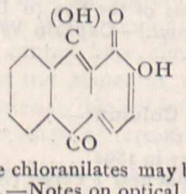
### LONDON.

**Chemical Society,** March 2.—Dr. J. H. Gladstone, vice-president, in the chair. The following papers were read:—The magnetic rotation and refractive power of ethylene oxide, by W. H. Perkin. The magnetic rotation of ethylene oxide is remarkably low, and the refractive power is also below the calculated value.—The origin of colour (including fluorescence), vii. The phthaleins and fluoresceins, by H. E. Armstrong. The author has previously taken exception to the formulæ usually assigned to phenolphthalein and its congeners; the exhibition of colour by these substances could not be accounted for by the formulæ generally ascribed to them. The correctness of the author's views has now been demonstrated by Bernthsen and Friedländer independently. The former chemist has shown that the rhodamines afford true ethereal salts, proving that they form carboxy-compounds and not lactone derivatives. Bernthsen also points out that the characteristic development of colour observed on adding alkali to phenolphthalein is probably due to the hydrolysis and subsequent conversion of the colourless lactone derivative into a quinolic compound; the latter then suffers dehydration, affording a coloured quinonoid derivative:—

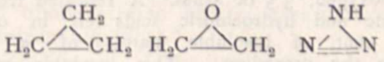
$$C_6H_4\begin{cases} CO \\ C \end{cases}\!\!>O \;\; \underset{\qquad}{=} (C_6H_4 \,.\, OH)_2 + H_2O = C_6H_4\begin{cases} CO_2H \\ C(OH)(C_6H_4 \,.\, OH)_2 \end{cases}$$

$$C_6H_4\begin{cases} CO_2H \\ C(OH)C_6H_4 \,.\, OH \\ \quad | \\ C_6H_4 \,.\, OH \end{cases} = H_2O + C_6H_4\begin{cases} CO_2H \\ C \,.\, C_6H_4 \,.\, OH \\ \quad \| \\ C_6H_4O \end{cases}$$

Friedländer also has lately shown that phenolphthalein and hydroxylamine interact in alkaline solution with formation of a hydroxime; this and other evidence has led him to the opinion that in their coloured state phenolphthalein and the allied phthaleins which behave similarly towards alkalis, are all quinonoid compounds. The fact that the rhodamines yield ethereal salts is also remarked in a patent specification by a German colour firm. The author considers the recognition of the quinonoid nature of the rhodamines and fluoresceins to be an important argument in favour of the views that fluorescence is a form of colour, and that all quinonoid derivatives would be visibly fluorescent were it not that the rays which cause the fluorescence sometimes become absorbed in the solution.—The origin of colour, viii. The limitation of colour to truly quinonoid compounds. Change of colour as indicative of change of structure, as in the case of alizarin, by H. E. Armstrong. A quinonoid compound may be defined as a *hexaphene*, *i.e.* an unsaturated cycloid composed of six "elements," of which two are C⊃R″ groups in either para- or ortho- positions. Coloured substances generally appear to fall within this definition; the few exceptions to the rule may be explained either by the author's view of isodynamic change or as resulting from the presence of traces of impurity. Some of the keto-chlorides prepared by Zincke possess an intense yellow colour, although containing the group—$CCl_2$—CO—; it is, however, not improbable that in such substances the group $CCl_2$ is the true equivalent of the C⊃R″ group. The usual constitution assigned to alizarin does not explain its red colour, red being the characteristic colour of the orthoquinones; the colour may be accounted for by regarding alizarin as an isodynamic form of dihydroxyanthraquinone thus:—



The red colour of the chloranilates may be explained in a somewhat similar manner.—Notes on optical properties as indicative of structure, by H. E. Armstrong. From a consideration of the refractive and dispersive powers of the metallic carbonyls, the author anticipates that quinonoid compounds generally will be found to possess specially high refractive powers. There are indeed experimental data supporting this view—anthracene, a hydrocarbon which is probably quinonoid in structure, having a high refractive power; further evidence is afforded by the specific refractions of the ortho- and para-nitranilines. The author then proceeds to discuss the orthodox formulæ for trimethylene, ethylene oxide, and diazoimide—



contrasting these substances with nitrous oxide; he contends that the above structural formulæ have no real justification, and that latent affinities may exist in these compounds just as in carbonic oxide. Thus nitrous oxide may be regarded as <N – O – N>, and diazoimide as < N – NH – N >. The influence exerted by the ethenoid and benzenoid groups in organic substances upon their refractive and dispersive powers, is also considered.—The origin of colour, ix. Note on the appearance of colour in quinoline derivatives and of fluorescence in quinine, by H. E. Armstrong. From considerations based upon the previous notes, the author shows that any amido-derivative of quinoline might become quinonoid in structure, owing to a change from the centric to an ethenoid form, and would hence be coloured. Similarly, an ethenoid form of naphthalene would be quinonoid; it is therefore possible that the fluorescence exhibited by many derivatives of this hydrocarbon is characteristic of the pure substances, and does not always originate in impurities.—The ethereal salts of glyceric acid, active and inactive, by P. Frankland and J. MacGregor. The authors have prepared and characterised a number of ethereal salts of inactive and lævo-glyceric acid; they point out regularities between the rotatory powers of the active salts of a somewhat similar nature to those observed amongst the ethereal salts of tartaric acid.—Formation of the ketone 2 : 6-dimethyl-1-ketohexaphane, by F. S. Kipping. On distilling the calcium salt of dimethylpimelic acid with soda lime, an oil is obtained which contains a ketone of the composition $C_8H_{14}O$. This ketone is apparently a dimethylketohexamethylene; it is doubtless a homologue of the ketone recently prepared by von Baeyer by distilling calcium pimelate with soda lime.—Note on the interactions of alkali-metal haloids and lead haloids, and of alkali-metal haloids and bismuth haloids, by Eleanor Field. By boiling potassium or ammonium iodide with lead haloids in aqueous solutions, double compounds are obtained, whose composition depends upon the proportions in which the constituents are used. Salts of the compositions, $3PbI_2 4KI$, $3PbI_2 4NH_4I$, $PbI_2 3PbCl_2$, $PbI_2 5PbCl_2$, and $PbI_2 2PbBr_2$, are described. The interactions of haloid salts of the alkali metals with bismuth haloids lead to the formation of compounds having the following compositions—$BiBrCl_4K_2$, $BiClBr_4K_2$, and $BiCl_3Br_3(NH_4)_3$. The composition of the products obtained depends, not only on the proportions in which the reacting salts are employed, but also on the nature of the halogens and the metals.—An isomeric form of benzylphenylbenzylthiourea by A. E. Dixon. Phenylthiocarbimide and dibenzylamine interact to form the compound $PhN : C(SH) . N(C_7H_7)_2$, isomeric with the thiourea $C_7H_7N : C(SH) . NPh . C_7H_7$, melting at 103°, previously obtained by the author from benzylthiocarbimide and benzylaniline; the new substance melts at 145–146°.—A new atomic diagram and periodic table of the elements, by R. M. Deeley. The author constructs a new atomic diagram of the elements by plotting "volume heats" against "volume atoms." The volume heats are the products of the specific heats and densities, whilst the volume atoms are obtained by dividing relative density by atomic weight.

### PARIS.

**Academy of Sciences,** March 27.—M. Lœwy in the chair.—The two candidates selected as competitors for the place of *Astronome Titulaire* at the Paris Observatory were: In the first place, M. Prosper Henry; in the second, M. Paul Henry.—On the construction of the chart of the heavens, and the determination of the co-ordinates of the centres of the negatives, by M. Lœwy.—On the organic substances constituting vegetable soil, by MM. Berthélot and André. "Humus" may be defined as that portion of the remains of vegetation which resists the action of the air and lower organisms, and remains as an insoluble residue in the soil, supplying the roots of the higher plants with nitrogen, sulphur, phosphorus, alkalies, &c. One specimen of earth freed from all visible plant remains, cellulose, and carbohydrates, taken from the experimental soil of the Vegetable Chemistry station at Meudon, contained 19·1 parts of organic carbon, 1·5 of hydrogen, 1·7 of nitrogen, 11·9 of organic oxygen, total 34·2 parts of organic matter. Some of the principles could be isolated by dissolving them in alkalies, and reprecipitating by acids. These were found to contain 55·2 per cent. of carbon, 6·8 of hydrogen, 3·0 of nitrogen, 35·0 of oxygen, 3·5 of ashes. A repeated treatment with hydrofluoric and hydrochloric acids left in one instance 1·4 per cent. of insoluble matter of a constitution similar to the preceding. This insoluble matter acted upon solutions of potassium salts in much the same manner as artificial humic acid obtained from sugar. It forms potassium compounds which are capable of resisting even prolonged washing by rainwater. This explains the "absorbing" action of the soil upon the alkalies, and especially upon potash.—On the interference fringes of grating spectra on gelatine, by M. A. Crova.—Researches on samarium, by M. Lecoq de Boisbaudran.—Remarks on the native iron of Ovifak and the bitumen of the crystallised rocks of Sweden, by M. Nordenskiöld. Among the blocks of native iron brought from Ovifak in 1870 there was one of about 40 kgr. which it was impossible to saw or to cut. It is now supposed that this is due to black diamonds disseminated through the iron. Considerable masses of bitumen are found in the crystalline rocks of Sweden, notably near Norberg and Dannemora. One of the two kinds found gives a large number of distillation products and leaves hardly any ashes. The other resembles anthracite. It yields little on distillation, and leaves much residue on combustion. This residue contains, besides silica, iron, lime, magnesia, &c., some oxide of nickel, uranium (3 per cent.), cerium, and yttrium, the three last in the form of carbon compounds resembling nickel carbonyl. These also occur in carbon forming large nodules in the oldest sedimentary strata of Sweden, the alum schists.—Observations of small planets made at the Toulouse Observatory, by M. B. Baillaud.—The Bielids, by P. François Denza.—On orthogonal correspondance of elements, by M. Alphonse Demoulin.—On the possibility of defining a function by an entire divergent series, by M. H. Padé.—A new sclerometer, by M. Paul Jannettaz.—On the indications of water-level in boilers by a glass tube, and their influence upon explosions, by M. Hervier.—On initial capacities of polarisation, by M. E. Bouty. The electricity absorbed in virtue of capacity of initial polarisation is entirely recoverable, on the condition of employing for the discharge an external circuit of negligible resistance.—On the distillation of mixtures of water and alcohol, by M. E. Sorel.—A general method for the calculation of atomic weights according to the data of chemical analysis, by M. G. Hinrichs.—On the formation of gallanilide, and on its triacetyl and tribenzoyl derivatives, by M. P. Cazeneuve—On the lakes of Sept-Laux (Isère) and La Girotte (Savoie), by M. A. Delebecque.—On a means of preserving beetroot plants and economic or ornamental young vegetables against the attacks of greyworms (*Chenilles d'Agrotis*) and other insect larvæ, by M. A. Laboulbène; with remarks by M. Chambrelent.

BERLIN.

**Physiological Society**, March 3.—Prof. du Bois Reymond, President, in the chair.—Dr. J. Munk gave an account of one part of the experiments on the nutrition of fasting-men, which he had carried out in conjunction with Messrs. Lehmann, Müller, Senator, and Zuntz. The same observers having some years ago made experiments on the fasting-man, Cetti, whose outcome was not in accord with the results of experiments made on dogs, they had more recently experimented again over a period of six days on another fasting-man, Breithaupt. This man's nutrition was followed for several days, on an ordinary diet, before the period of fasting, and again after the latter had ended. During the fast the patient was at liberty to consume as much water as he pleased, the amount taken being carefully noted. The following were the results of the experiments. The output of nitrogen sank slowly and continuously during the whole period of fasting. The urinary phenol increased in amount up to the fourth day (the sixth day in Cetti's case) and then sank to a minimum. Indol was only found in traces, and acetone was absent altogether. The amount of chlorine, as of alkali, diminished progressively, and continued below the normal even after food was once more taken. The urine contained a large quantity of phosphoric acid, as also of lime and magnesia. Prof. Zuntz reported on the respiratory interchange of the above man. When at rest the intake of oxygen was the same as that of a normally fed person twelve hours after a meal. The respiratory quotient varied from 0·66 to 0·69, and was thus less than that due to the oxidation of fats alone (0·7), or of proteids alone (0·8). During the fast the patient's power in turning a wheel against friction was the same as that observed when feeding, but fatigue set in much sooner, and was most marked in the cardiac muscles. During the earlier days of the fast, the consumption of oxygen when working was the same as for a normal person, but later on it became greater. The after-effects of work lasted longer than when food was taken. The speaker regarded the above extremely low respiratory quotient during the fast, as due to the possibility that the proteids split up into glycogen and some other substance, which was then oxidised and gave rise to the small quotient observed. In support of this view experimentswere made by Dr. Vogelius on the construction of carbohydrates in the fasting body. In the fasting animals on which the experiments were carried out, all glycogen was removed by moderately strong doses of strychnine. After this they were sent to sleep for eighteen hours by means of chloral-hydrate, and at the end of this period glycogen was found in considerable quantity both in their liver and muscles—glycogen which must presumably have been formed from the metabolism of their own proteids.

**Meteorological Society**, February 7.—Prof. von Bezold, President, in the chair.—The President gave a short account of a paper he had recently published in the *Sitzungsberichte* of the Berlin Academy on the thermal exchanges of the atmosphere, and entered into details as to the general propositions therein put forward. The latter are as follows:—1. The total radiant heat received by the whole earth in a year is equal to the total amount given off by radiation in the same period. 2. The total heat received by any portion of the earth or the atmosphere is on the average equal to that given off by the same portion. 3. The total heat received and given off in the course of a year is not the same for different portions of the earth or atmosphere: in some parts the amount received is greater than that given off, and *vice versâ*. 4. The heat received by given portions of the earth or atmosphere during any given period of the year is in general not equal to that passed off during the same period. 5. The total amount of heat taken in at the surface of the whole atmosphere during a given portion of the year is not necessarily equal to that given out at the same surface during the same period.

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